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MILLING-MACHINES AND MILLING-TOOLS.

By JOSHUA ROSE.

THE position occupied by the milling-machine in modern practical mechanics is almost as important as that occupied by the lathe or planing-machine. In getting out work by the aid of either of the latter, the size and uniformity of the work depend upon the accuracy in measurement, and hence upon the skill of the operating artisan, hence a skilled and expert workman is necessary to the use of each lathe or planer. In the case, however, of a milling-machine, the skilled mechanic has but to properly set the machine and the chucks necessary to hold the work, and a less skilful operator may be assigned to continue the operation of getting out any number of similar pieces of work, with the assurance that uniformity of size and form and equality of finish may be with ordinary care assured. Then, again, intricate forms and shapes of work may be exactly and easily duplicated by the employment of milling-tools, which would be impracticable were the same work operated upon by a planing-machine; especially is this the case in work of complicated form. Suppose, for instance, it were required to cut out a corrugated surface such as shown in Fig. 1,

Fig. 1.

it would be a difficult matter to produce with a planing-machine one such a piece of work quite true and with a smooth and polished surface, because the tool would be liable to spring from the broadness of cutting surface, which would, in the case of wrought-iron and steel, cause the tool to spring into the softer and away from the harder parts of the metal; and in the case of any metal it would be quite difficult to feed the tool so as to insure exactitude and avoid tool-marks at the junction of the cuts taken by the round-nosed and curved tools; whereas, with a milling-tool, properly made (and it is no difficult matter to make such a tool), the operation is so simple that it may be performed with comparatively unskilled labor.

One of the main advantages of milling-tools is that the work will, in nearly all cases, be true, even, and smooth, even though the tool itself be a little out of true.

Fig. 2a.

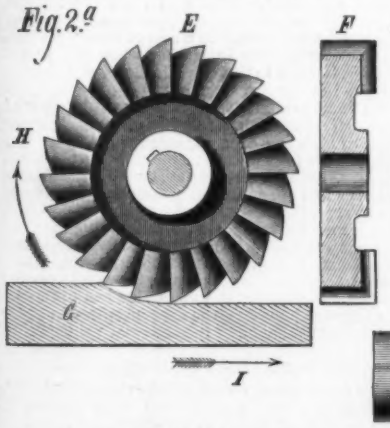
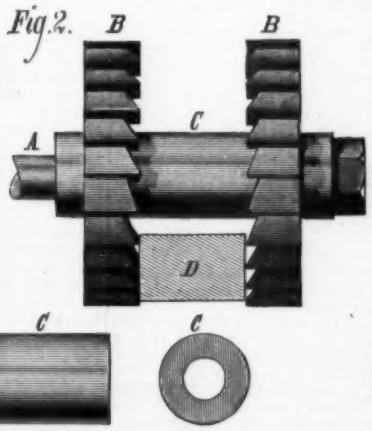
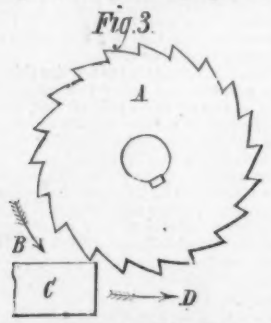


Fig. 2.



Suppose, for example, we require to mill the side faces of a rod, and we employ for the purpose the milling-bar and cutters shown in Fig. 2, in which A A represents the spindle of a milling-machine, and B B are milling-cutters with the distance washer C interposed between them to regulate their distance apart; D representing a piece of work being

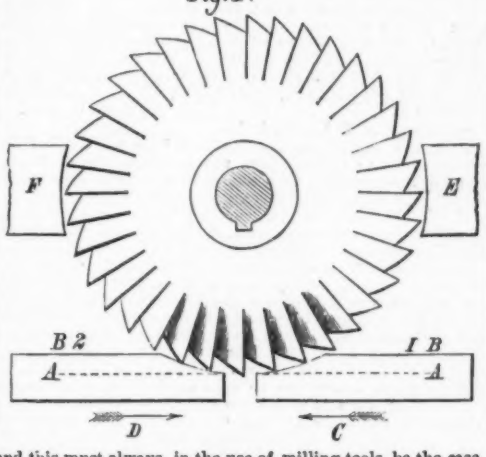
Fig. 3.



fed between the revolving cutters B B. Now, it is evident that even were the cutters out of true, the pieces of work would all be cut to one size, because the projecting teeth of the cutters will come into contact with and operate upon each part of the surface of the work being operated upon, the only difference being that the work will be cut narrower with the same thickness or length of washer than it would be were the washers true.

In Fig. 2a, E represents a view of the face of a milling-cutter, and F a sectional view of the same, while G represents a piece of work passing under the cutter and not between the cutters, as shown in the case of the work D. The arrow H denotes the direction in which the cutter E would require to revolve, and the arrow I the direction in which, in that case, the work would require to travel; from which it will be perceived that the lateral strain placed upon the work by the cut is in a direction to force the work back from the cutter,

Fig. 4.



and this must always, in the use of milling-tools, be the case, and is a very important consideration for the following reasons:

From the breadth of cut taken by a milling-tool, and from the acute angle at which the teeth of the cutter strike the cut when the work passes below the circumference of the cutter, the strain due to the cut is immense; and were this strain in a direction to drag or draw the work below or towards the cutter, the latter would, from the spring of the spindle, rip into the work and tear its own teeth off. Thus in Fig. 3, suppose A to be a milling-cutter revolving in the direction of the arrow B, and C to be a piece of work travelling in the direction of D, it will be readily perceived that there will be an enormous strain in a direction to force the work from its chuck or clamps and drag it under the cutter.

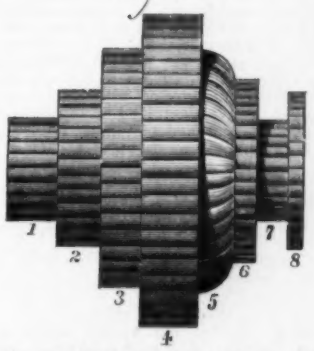
The work being held sufficiently firm, can not, it is true, move in that direction faster than the rate of feed will permit; but the teeth grip the work, the cutter springs forward and attempts to ride like a spiked wheel over the work, and the cutter-teeth break from the undue pressure; and therefore it is that in milling work of every kind whatsoever, the direction in which the work is fed should be such as to tend to force the work away from the cut; or, in other words, the cutters should cut under the cut, not only because of the above imperative reasons, but for the following additional ones.

The skin of iron or brass castings and of iron or steel forgings is considerably harder than is the interior of the metal, in addition to which there is frequently scale in the one case and sand in the other to contend with, so that if the cutting edge of a tool comes into contact with the outer skin of the work, the keenness, and hence the cutting value of the tool or cutter, becomes rapidly impaired; and milling-cutters being expensive tools to make, it is desirable that their cutting edges and qualifications be preserved as long as possible. Suppose, therefore, that in Fig. 4, from A to B represents the depth of cut on two pieces of work, one travelling beneath the cutter in the direction of the arrow C, and the other in the direction of the arrow D, and that the upper surfaces B, in each case, have a hard surface-skin upon them: it becomes apparent then that in the case of the piece represented at 1, the cutter-teeth will, after the cut has once started, meet the soft metal and cut under the skin till the cut has ended, so that, save at the very commencement of the cut, the cutter-teeth would never meet or come into contact with the hard surface-skin; while in the case of the piece of work, 2, the teeth would in every instance strike the hard skin first. If the piece of work E were held in the position shown, it would strike the scale, whichever way the cutters ran or the work was fed; and the same remark applies to the piece of work F. There is this difference, however, between the two latter positions: with the cutter revolving in the direction shown, the strain of the cut would be in a direction to lift E from the machine-table, rendering it very liable to spring and difficult to cut; while the strain on F would tend to force it down upon the table, which would be far preferable.

When the side faces of the cutters operate, they must be made right and left—that is to say, the teeth of one cutter must slope in the opposite direction to those on the other cutter, so that when the two are placed opposite to one another, as shown in Fig. 2, the teeth of both will stand in a direction to accommodate the direction in which the cutters revolve. To cut side faces of any required width, we have only to vary the width apart of the cutters by the washer C, in Fig. 2; while to cut curves and shoulders, the periphery only of the cutters can be used. Thus, suppose it were required to cut out the form shown in Fig. 5, the outline of the cutter would

Fig. 5.

Fig. 6.



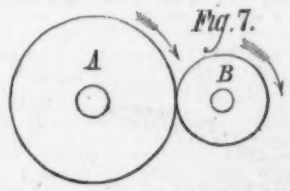
require to be as shown in Fig. 6, but it would be a tedious and difficult matter to get up a solid cutter of such a shape on account of the difficulty of cutting the teeth; hence, all such compound forms are produced by making separate cutters, each of its requisite form, size, and width, and then placing them together to make up the whole. Thus the figures from 1 to 8 each represent a separate cutter. It is obvious then that there is scarcely a limit to the forms capable of being smoothly cut and uniformly reproduced by such cutters. The Morse Twist Drill Company cut the threads upon their taps, and give the sides of threads a slight amount of clearance back from the cutting edges by the use of milling-tools, producing a tap equal, in every respect, to those producible in the lathe, and being remarkable for uniformity of size and finish.

Milling-cutters of small size are made of solid cast-steel; for larger sizes, the body is made of wrought-iron, while the faces whereon the cutting-teeth are to be formed have steel welded on them.

After the cutters are bored and turned to the requisite size and shape, the spaces necessary to the formation of the teeth may be cut by a milling-cutter; and here it may be well to note that it is advisable to keep the teeth sufficiently wide apart to give plenty of room for the cuttings to escape; even in cutters for gear-wheels, coarse teeth—that is, those wide apart—will cut quicker and smoother than fine ones, and have the advantage that they entail much less labor in both the manufacture when new and resharpening when dull. After the spaces are cut out and the teeth formed, the cutting edges must be carefully filed up and the cutter hardened. If, however, the faces of the cutters are plain and the spaces between the teeth are sufficiently wide to admit of the teeth being ground by an emery-wheel (as is usually the case, and as should be the case whenever it is possible) the sharpening process should be performed as follows:

The cutter, after being hardened, should be revolved rapidly in the lathe in one direction, while an emery-wheel revolves at a high speed in the opposite direction, as shown in Fig. 7,

Fig. 7.



A representing the cutter and B the emery-wheel; the emery-wheel should be fed to the cutter just sufficient to true the cutting edges, after which the necessary clearance and sharpening may be given to the teeth as follows: Beneath a revolving emery-wheel, and quite parallel and true with the spindle on which the emery-wheel revolves, there is provided a stationary adjustable mandril of such a size as to neatly fit the centre hole in the cutter to be operated upon; which mandril is of a sufficient length to permit the cutter to slide along it

and stand wholly on either side of the emery-wheel. The height of the mandril is adjusted so that the emery-wheel will, when brought into contact with the cutter (while the latter is upon the mandril), take off just sufficient to sharpen and give clearance to the teeth. It is obvious, however, that some guide is necessary to insure that the teeth of the cutter shall pass under the emery-wheel in the necessary and in an exactly uniform position, which object is accomplished by providing an adjustable stationary guide or gauge, against which one of the teeth of the cutter shall slide while the other is being ground. The operation is thus to place the cutter on the mandril and adjust the latter to the requisite height, to then adjust the guide so that when the cutter is moved forward it will first come into contact with the guide, against which the cutter is held by the hand, while it is at the same time passed under the emery-wheel. It is obvious that by this means either circumferential or side-face teeth may be sharpened and maintained true if the bearing of the cutter upon the mandril is sufficiently long and of sufficiently accurate fit to keep the cutter steady. There are other devices for large cutters in which the latter are stationary and the emery-wheel traverses along the teeth, which plan is for large cutters preferable to that first described; the principles involved are, however, the same in both cases.

It must be remembered that, in using the emery-wheel for this purpose, it *must* run under its cut for the reasons already explained by Fig. 3 and its accompanying explanation.

It is obvious that in the case of long cutters having circumferential teeth, the excessive strain due to each tooth striking the cut will cause the mandril carrying the work to spring away from the cut, the effect being that the finished surface of the work will be slightly waved. To remedy this defect, the teeth of the cutter should be made to run slightly spiralled and not straight across the length of the cutter, so that the cutting edges will be taking and leaving the work continuously, and hence the spring alone referred to will be at all times equal. The same object is obtained in compound cutters, such as shown in Fig. 6, by cutting the key or feather-ways in the cutters so that their teeth will not stand in a line one with the other.

TRIAL OF THE LOUGHRIDGE AIR-BRAKE.

THE Baltimore *American* of March 1st says: "A highly important and interesting trial was made yesterday of the Loughridge air-brake on a portion of the Washington Branch Railroad, near Alexandria Junction, during which a train of ten cars, engine, and tender, running upon a level track at a speed of 42.6 miles per hour, was stopped within a distance of 589 8-12 feet, or in 46 feet less than the entire length of the train, and in 16 seconds' time. The results of the experiment were entirely satisfactory, and the stop was made without sliding the wheels. The judges of the experiments were Wm. H. Shock, Chief Engineer United States Navy; J. M. Hood, President Western Maryland Railroad; G. G. Foreacre, General Manager Orange and Alexandria Railroad, and E. W. Barker, of Baltimore."

[American Builder.]

AMATEUR MECHANICS.

A GOOD thing to give a boy is a chest of tools. They should be of the best quality, just as good as the market affords. It is surprising what progress he will make in a little time in learning how to use them, what amusement they will afford him, and the possible benefit the knowledge he acquires may be to him in after-life. Just now it is quite the fashion to work in wood. In city homes, even, delicate ladies are learning the art of wood-carving, and thousands of beautiful ornaments are made with the fret-saw. There is fair prospect of a genuine revival of the art of wood-carving, and it is not improbable that, long ere the century closes, we may rival the works of the old masters of this noble art; and that the best work may be done, too, by those who were born to a life of leisure, who took it up and pursued it from sheer love of it.

But mechanical tools furnish a delightful means of recreation for adults, for people whose brains are overtaxed, and a well-equipped workshop is something worth having. A friend of ours, an ex-judge and a lawyer of note, surprised us, not long since, while on a visit at his house, by an exhibition of this kind. With the exception of a forge, the shop was very complete. There were lathes for turning wood and iron, drills, chisels, and almost every kind of tool for working in wood, all in fine order, and systematically arranged. And the judge had made good use of them. Every room in his house bore testimony to his industry and mechanical skill. There were picture-frames and easels, and tables that could be folded up—we wish we had made a drawing of one most ingeniously constructed—and scores of articles useful and ornamental; and all this the result of play, not of work.

The celebrated Dr. John Todd, a sketch of whose life has just been issued by the Harpers, was quite a noted example of the amateur mechanic, although there is no evidence that he achieved very much skill; he was rather more of a tinker than workman, at least so we judge from the account given in his life. His shop, however, was a very elaborate affair, and contained a wonderful variety of appliances for executing mechanical work. He was a clergyman, and fine tools were his hobby, and his parishioners knew his weak point, and so contributed to his collection; besides, he did not spare time or money, himself, in securing them. These amateurs sometimes go to great lengths when once they are thoroughly in earnest. Dr. Todd, it is said, would spend days, and travel many blocks, when in New-York, in search of some new tool for his shop. And he was very methodical, kept all in perfect order, and could place his hand on any article he wanted, even in the dark. It is a very entertaining picture given of this hard-working clergyman going from his sermon to his shop, and from his shop back to his sermon; the one work, and the other play; and the play of the shop entered into in order that he might make the better sermon.

Tools can be collected just as we collect books and pictures; it is not necessary to purchase all we require at once. The first thing required is to find a place for them—some room where they can be kept under lock and key; for, let it be understood, when they become the public property of the household they lose edge and place. The room should be large enough for a work-bench, one or two lathes, and a portable forge; the latter is by no means an unimportant item if the shop is to be well equipped, and it takes up but little room. An amateur can soon learn many tricks of smithing by careful observation, and the art is a very handy one; for it is not convenient to go in search of a smith when a cold-chisel or a drill requires tempering. There is no mystery whatever about working steel, if one is careful to never heat it beyond a cherry red; and any boy can learn how to temper a tool. The modern portable forge is well worthy of the consideration of all who work with edge-tools, and should be considered indispensable to the wood-working mechanic where he has not ready access to the smith.

The brain-worker will find health of body, as well as amusement, in turning his attention to mechanical work; and if he is possessed of any degree of ingenuity, it will soon have a fascination for him. It will give him rest from the distracting cares of professional life. On the other hand, the mechanic finds recreation in books and the mental activity which they inspire. Work and play are but relative terms after all, and it is well if we can obtain recreation in some way that will be of practical use to us.

A DIVINING ROD EXPERT.

A COMPLAINT has been filed in the Third District Court by A. Peck against Michael Castle, in which he charges that, in 1872, he and Castle entered into a contract, whereby Castle agreed to pay his expenses to and from Virginia City, for the purpose of pointing out to P. Deidesheimer, at that time superintendent of the Ophir mine, where the ore body of said mine lay; and that if the ore body should be found after nine months of regular work in the course that Peck would point out as the course of said ore body, then he, Castle, would deliver to Peck 100 shares of Ophir company's stock at the price of $50 per share.

The document on which this suit is brought is a peculiar one, and is in the following words:

"San Francisco, March 2d, 1872.—Michael Castle, on behalf of a party of gentlemen owning a quantity of Ophir company's stock, and having power to act for them, agrees with Mr. Peck to pay his expenses to and from Virginia City, for the purpose of indicating to the superintendent, P. Deidesheimer, where he asserts there is a body of ore. Should it prove by future working in the direction Mr. Peck indicates, and when the work is done that may develop it, even only to show it is there, I, on behalf of the aforesaid gentlemen, and on my own security and distinct fulfilment of this agreement, will deliver Mr. Peck 100 shares of Ophir company's stock, at the price of $50 per share, at his option, within nine months from this date. MICHAEL CASTLE.

"Witness: A. H. Lissak, Jr."

Peck, the plaintiff, alleges that he did go to Virginia City and point out to Deidesheimer the locality of the ore body, and that the work was for a time carried on as he directed it should be. But, he says, this was done for only a few months, and then the miners were taken from the proper course and made to work in another part of the mine, in violation of Castle's agreement with him.

The plaintiff then alleges that in the fall of 1874, the miners having been allowed to work in the course he had before marked out, the body of ore was discovered where he told Deidesheimer it would be; and that the new shares of stock advanced to and were worth on the market of San Francisco $350 per share, making $200,000 as the value of the one hundred old shares of stock he was entitled to have of Castle at $50 per share. Therefore he asks for $200,000 in damages. "Professor" Peck is well known in Nevada, and considers himself an expert in pointing out ore bodies by the aid of the "divining rod," but whether he located the ore body referred to by this means we do not know.—*Mining and Scientific Press.*

IMPORTANT TRIALS IN GUNNERY.

PRELIMINARY trials have now been completed with a new experimental field gun, designed in the Royal Gun Factories at Woolwich. It is of the same weight as the 9-pounder, namely, 8 cwt, and of the same external size and appearance, but so modified in other respects that instead of a 9-lb. shot it will carry a projectile weighing about 13 lb., while the powder charge will be at the same time increased from 1 lb. 12 oz. to 3 lb. The calibre of the bore has been slightly increased from 3 inches to 3.2 inches, and the chamber has been specially contrived to carry a special cartridge, so as to consume profitably a large charge of powder in so small a gun. In the experiments which have taken place a poly-groove system of rifling has been adopted, and the new gas-check has been employed to follow the grooves in the place of the usual studs, and thereby create the necessary rotation, after the plan of Captain Blakely. The result has been greatly to increase the range of the gun, as well as the power of the shell. The velocity obtained has, with a special powder, reached as high as 1700 feet per second, and in the trials which have this week concluded, it has been shown that, with an elevation of 5 deg., a range of 3000 yards can be depended upon. A complete revolution in the national field artillery may result from these experiments. Some other novelties in gunnery are being introduced by Mr. Hotchkiss, an American inventor. He is now in treaty with the French Government for the manufacture of a revolving cannon, something on the Gatling principle, only that it is to carry shots of 1 lb. weight, and he is now anxious to extend his system of breech-loading to the English field guns. For this purpose he has had a gun made by Mr. Vavesseur, a steel breech-loader of about 8 cwt., which, except in having a wedge, does not differ in any important degree from the ordinary shoulder sporting-rifle with the central fire. This has been fired at the Royal Arsenal proof-butts, and appears to have obtained a fair amount of success.—*Iron.*

PROPOSED NEW TUNNEL UNDER THE THAMES.

A BILL is before Parliament for the incorporation of the Thames (Tower) Tunnel Company, for the construction of the tunnel for carriage-traffic beneath the River Thames, for the purchase of the existing Tower Subway, and the winding-up of the Tower Subway Company. The project consists of a tunnel beneath the Thames, with approaches to it on the northern and southern sides of the river. The northern approach commences near the southern end of the Minories, on Little Tower-hill, passes through Postern row, and thence being carried down spirally on plan it passes under the Tower ditch to the banks of the river; the tunnel is then formed beneath the river to the southern bank to Pickle Herring street, and thence the road rises by a spiral on plain to the level of Tooley street, at a point nearly opposite to Barnham street. On the northern side there is a second carriage-road approach to the tunnel, commencing at Great Tower-hill at about 30 yards north of the principal entrance to the Tower, and thence being carried along Tower-hill to a junction with the road already described on the northern side at Trinity square. This approach is specially intended to accommodate the traffic from Eastcheap, Tower street, and Lower Thames street. All the approaches to the tunnel are to be 28 ft. in width; the tunnel beneath the Thames is to be 23 ft. 6 in. in width; it is for the most part level, the remaining portions of the lines of approach will have gradients of 1 in 40. As the object is largely to relieve London Bridge of traffic, and especially of the heavy traffic, easy gradients have been deemed essential by the promoters. The tunnel and works above described are intended for the accommodation of vehicular traffic only, but in order to provide for pedestrian traffic it is intended to purchase the existing Tower Subway. The present Tower Subway, which is 6 ft. 7 in. in diameter, is to be enlarged so as to make it 11 ft. in width; it is now approached on both sides of the river by flights of stairs, which are to be abolished, and the communication with the street surface made by covered sloping ways with gradients of 1 in 10. The northern entrance to the subway will be on Tower-hill near to Trinity square, the southern entrance to Tooley street, nearly opposite to Barnham street. As the company intends taking down the whole of the property in Postern row and the southern side of George street, it is proposed to widen and improve George street, and to stop up and appropriate for the intended carriage-way approach to the tunnel portions of Postern row and Trinity square. On the southern side of the river it is proposed to divert Vine street. Power is also sought to divert and alter the lines or levels of certain streets for the purpose of connecting them with the approaches to the tunnel, but these alterations in public ways are all outside the city. Also to make and maintain shafts or openings from the surface of any road or street for the purpose of lighting and ventilating the approaches, the number, size, and position of such shafts being agreed upon between the company and the local authorities. These shafts are to be covered by gratings or erections of an ornamental character, the design of which is also to be approved by the local authorities. Clauses are inserted in the bill by which the company shall give notice before breaking up any streets, for reinstating any streets so disturbed, and for the protection of the sewers of the city of London. There are also clauses in the bill for authorizing agreements with the Corporation, the Metropolitan Board of Works, and the local authorities in whose districts the proposed works are situated, for the purchase and maintenance of all or any part of the works. Tolls are to be taken for passing through the tunnel. The area of public way scheduled in the city of London is 1r. 14p., and of private property 15½p., making together 1r. 29½p.

[International Review.]

THE CHEMICAL ACTION OF PLANTS.

By Prof. AUGUST VOGEL.

THE oldest manual of chemistry, "Institutiones Chemicæ," published 1763, says: "The science of chemistry, in the last twenty or thirty years, has undergone very great transformation." This assertion, true more than a hundred years ago, when chemical investigations could be made only by a very limited number of learned men, is truer still to-day. We may fairly assert that no science has ever undergone larger and more rapid advances and transformations. The change of systems, general theories, and methods of investigation have been continual. But the most important transformation of the last twenty or thirty years is surely to be found in the fact that chemical science has now become the common property of the cultivated classes, offering a field accessible to the widest circles of society. The most celebrated inventors and investigators, Justus von Liebig among the first, have not disdained to disclose the treasures of their knowledge to the public in general. It will suffice to mention Liebig's celebrated "Chemical Letters," published in the *Augsburger Allgemeine Zeitung*, a daily and political newspaper which was at that time, as it is now, one of the most influential periodicals published in the German tongue, known and read among German people throughout the world. No scientific publication ever had a success comparable to that attained by these "Chemical Letters;" and even now, as examples of popular prosentations of scientific topics, they stand unrivalled. From that time, the learned professors began to give up their ancient system of announcing and describing new investigations in a sort of lapidary style, and ceased to think themselves humiliated when the public took an intelligent interest in their publications, and proved its ability to share in their investigations.

Nowadays we find instructive dissertations on substances of special interest—on water, air, phosphorus, sulphur—in every paper or review of high standing, and a daily increasing number of learned men are bent upon "popularizing" chemistry, just as physiology, physics, philosophy, and other sciences have, with more or less success, been popularized and made familiar. To be sure, this new method has met with many opponents, and it may be fairly admitted that the so-called popularization has often been no better than a superficial vulgarization of scientific topics; yet it can not be doubted that, in spite of some isolated failures, it has on the whole proved its general utility, and that popular discussion has diffused a vast amount of useful knowledge among people who were formerly ignorant of the simplest fundamental principles of science.

LIFE AND NUTRITION OF PLANTS.

Thus we may fairly assume that, chiefly through Liebig's excellent publications, the fundamental laws by which the life and nutrition of plants is regulated are no longer unknown to the majority of intelligent people. We all know that by the analysis of any plant, or part of it, we invariably find it to be chiefly composed of three or four elements: carbon, hydrogen, oxygen, and nitrogen. We know that the plants draw these necessary ingredients, not from the soil, but from air and water, and that the former supplies to them only the comparatively small amount of mineral ingredients which they require for their perfect development. Thus we may say that air and water are the sources and foundations of vegetable life.

But we ought not to forget that to acquire this knowledge was by no means easy, and that many thousands of experiments, and the labors of two or three generations, were consumed in the process. In fact, if we investigate closely, we soon perceive that the correct theory of vegetable life, as it is now universally acknowledged, was by no means obvious, or easy to discover. For instance, when we inquire into the assimilation of carbon by plants, we find that an immense quantity of it is contained in almost every natural soil. Falling leaves, rotten wood, or other vegetable matter decomposed in the soil, supply to plants immeasurable amounts of carbon; humus and turf are almost entirely composed of it. We can scarcely find fault with our fathers and forefathers, whose knowledge of the condition, and of the elements, of our atmosphere was a very imperfect one, for the simple assumption that plants take their necessary supply of carbon out of the soil, its natural basis, where large quantities of it are accumulated. It was anything but obvious or natural to suppose, and to learn by experiment, that the plants avoid the carbon mingled with the

soil, and extract it slowly and laboriously out of the carbonic acid which is contained, in small doses, in the atmosphere.

A mediæval naturalist says: "These wonderful beings—the plants—are our best friends, and nature has made them to be the source of the welfare and the misery of humankind. What would the world be without their leaves, blossoms, and fruits? An immense hospital, the home of thousand-fold suffering! And yet how little does ungrateful mankind care for them!" This enthusiastic friend of the plants evidently praises them for their manifold medical virtues; but heartily as we may join in his praise, we have learned to perceive a far greater influence of vegetable life upon "the welfare or the misery of mankind." We know that the plants which decompose the carbonic acid contained in the atmosphere, and supply it with oxygen, literally make it fit for the development and main- of human and animal life. To denominate them, therefore, "truest friends of humankind," inadequately expresses their true importance; we may call them more properly our *indispensable* friends, without whose aid our existence would be an impossibility.

NITROGEN AND NITRIC ACID.

No less singular than the absorption of carbon is the reception into the vegetable body of nitrogen. The atmospheric air contains about 78 per cent of nitrogen. What could seem more natural than that the plants would utilize it for their nourishment? And yet, strange to say, they are incapable of assimilating the nërial nitrogen; this element, indispensable as it is to vegetable life, can not be made use of otherwise than in new and complicated chemical combinations. If to judge nature and her laws in accordance with our narrow and limited perception were not altogether inadmissible, one might indeed be tempted to define these strange peculiarities as wilfull caprices.

We find in the atmospheric air, besides nitrogen and oxygen, two chemical combinations of nitrogen; namely, ammonia (nitrogen combined with hydrogen) and nitric acid (nitrogen combined with oxygen). Ammonia, an aëriform product of the decomposition of animal or vegetable matter, is everywhere found, in small quantities, in the atmosphere; and, by transmission from the latter, in every soil, and in water, from whence the plants absorb the quantities requisite for their development.

We know that their green leaves, aided by the sunlight, decompose the carbonic acid contained in the atmosphere. The recent researches, however, which were begun by Justus von Liebig have rendered it more than probable that the same leaves forward another interesting chemical process—the conjunction between oxygen and nitrogen. Liebig was likewise the first to discover and prove the presence of nitric acid and of ammonia in the air and the water. From the fact that the contact of atmospheric air, hydrogen, and the electric spark produces nitric acid, he inferred that the same process, repeated on a large scale by the effect of lightning upon the wet atmosphere—*i. e.*, by every thunderstorm—must produce the same result; and the analysis of rain-water showed that it really contained acertain amount of nitric acid. The quantity of nitric acid was found to be greater when the experiment was made in the daytime than when made in the night; and a particularly large percentage of the acid was obtained from water which had dripped in full sunshine from the green leaves of a tree. As we all know, a rainfall happening during strong sunshine is considered to be injurious to vegetation, and especially to the development of the green leaves, which often have a stained and seemingly burned appearance afterward. We also know that experienced gardeners, although they can give no theoretical reason or it, discourage the watering of flower-beds during the sunshine. It must be inferred from these facts that the falling raindrops, when shone upon directly by the rays of the sun, exercise a pernicious influence upon vegetation; and we may suppose, although there is as yet no positive proof of it, that the cause of this is the formation of nitric acid in the water. It would be interesting to see in this case, as in many others, a mere empirical observation confirmed by the development of scientific knowledge.

CHEMICALS USED BY PLANTS.

Thus we discover manifold chemical reactions in every manifestation of vegetable life. The plants decompose or generate nitric acid, carbonic acid, ammonia, etc., and are incessantly engaged in chemical operations, of which doubtless only the smaller portion has yet been revealed as the results of human research. Moreover, every part of the plant, the roots as well as the leaves, co-operate in this work. The absorption of the mineral ingredients of the soil through the latter is by no means a mere mechanical process. On the contrary, we know, through Liebig's researches, that every root secretes a fluid, whose nature has not been entirely revealed, but which has been distinctly recognized as a sort of acid, by which the absorption of minerals from the soil is greatly facilitated. The above-named naturalist very strikingly says: "The plants *attack* the soil with their roots." If we place polished plates of glass, rock-crystal, quartz, or flint-stone in the earth beneath the roots of a growing plant, we perceive, after a while, a marked dulness of the spots touched, from which we are led to conclude that these minerals, which resist the action of most known acids, have been corroded by the fluid secreted in the roots. The same effect, but to a much more marked degree, is produced upon weaker materials, such as lime or chalkstone, which are often found deeply scratched and incised by the chemical action of plant roots. The beginning of vegetation produces a sort of fermentation in the soil by which carbonic and nitric acid, ammonia, and other necessary elements of vegetable life, are brought forth and diffused through it in such a way that the roots may daily draw from it their requisite portion of nourishment. Above and underneath the earth, we find every plant engaged in slow but incessant and powerful chemical action.

PLANTS AS CHEMICAL LABORATORIES.

Plants are also invaluable aids to mankind in the accomplishment of many purposes which human skill and scientific industry do not, and perhaps never will, enable us to obtain otherwise. In them nature has provided for us an immense laboratory, in which the finest and most subtle, as well as the coarsest and commonest, chemical substances are distilled and heaped up for our advantage and profit. For instance, all of us know that potassa is one of the commonest, but at the same time one of the most important, of chemical substances; and that entire branches of modern industry are wholly based upon the use of this modest product of our chemical factories. Its natural sources are to be found in the feldspar, or rock-quartz, porphyry, basalt, and other minerals, of which, as we know, the bulk of our planet is formed, and which have been gradually changed, on its surface, into productive soil by the combined action of air and water. The feldspar, in particular, contains from six to fifteen per cent of pure potassa. Nevertheless it has been impossible until now, to extract the potassa otherwise than by a long series of difficult and costly manipulations; the potassa being always closely combined with argillaceous (clay-like) and silicious (flint or quartz-like) earth, from which it is extremely difficult and tedious to separate it. If we had no other means for accomplishing this work than our own skill and ingenuity, potassa, useful and indispensable as it is, would still be an extremely rare and precious substance. We can not wonder, under the circumstances, that for a long time its mineral nature and extraction remained altogether a mystery; and that it was reserved for the so-called organic chemist to make this important discovery. It was only by the subsequent analysis of a great quantity of different plants that the presence of potassa, in every variety of the soil, was proved, and the commoner or, according to which potassa had been considered as the mere product of vegetable life, and therefore denominated vegetable alkali, refuted. The roots of plants have the power of extracting the alkali from the nearly insoluble combinations with clay and silica, in which we find it diffused over the surface of the earth. They perform an operation which our laboratories and chemical manufactories are as yet wholly unable to perform on a larger scale, and offer us the ready product, potassa, in the ashes of certain well-kown and extremely common trees, shrubs, and vegetables.

Thus we let the plants work for us, let them store up the alkali in their bodies by gradual infiltration from the mineral soil, and have then merely to lixiviate (lench) their ashes. The numerous efforts which have been thus far made to change this state of things, and to extract potassa directly from the soil, have utterly failed; the skill of mankind cannot, in this respect, supersede the work of nature.

IMPORTANT CHEMICAL SUBSTANCES OBTAINED FROM PLANTS.

Ordinary firewood—pine, beech, etc.,—contains about two parts per thousand of potassa; still richer in this substance is the ordinary beet-root. It has been stated that one of the larger German sugar-manufactories sends to market about 6000 quintals of potassa per annum, thus securing a considerable secondary profit. It is a subject worthy of serious consideration whether such enormous quantities of alkali ought not to return to the soil, in the shape of artificial manure, in order to prevent its gradual exhaustion, especially since the beet-root, as we know, exhausts its chief nourishing ingredients in the course of a few years. As yet we are utterly ignorant as to under what form the potassa is contained in the living plant or its innumerable vesicles; we only know that it must be combined with organic materials which transform themselves into carbonic acid when the plants are reduced to ashes, because we find the vegetable alkali generally in the form of carbonate of potassa, which is identical with the substance commonly called potash.

The fabrication of soda is likewise extensively carried on by the plants; those which grow near to or in the sea, withdraw soda from the salt water, and deliver it to us in the shape of carbonate of soda, or soda-ash. However, the quantity of soda gained by the calcination of seaweed is infinitely small when compared to the enormous yearly consumption of this material. Human skill and industry have achieved here what they failed to do in the production of potassa: soda is more easily and cheaply produced by the chemical transformation of common salt than by the incineration, or reducing to ashes, of saliferous plants.

In other cases vegetation not only assists mankind in the production of useful and necessary substances, but we must confess ourselves to be directly indebted to it for the discovery of some of them. Up to the present day, we probably would have had no knowledge whatever of those useful twins iodine and bromine if nature herself, by means of vegetation, had not placed them in our way and within our reach. The source from which we derive the requisite amount of iodine is the ordinary saltwater of the ocean. Nevertheless it is contained in the latter in such infinitesimally small quantities that four millions of pounds (according to other calculations only one million) of it, when evaporated, would only leave a residuum of about three-quarters of a pound of iodine. In either case the dilution is carried to such a point that our means of perception and investigation would never have sufficed to secure any considerable amount of iodine from the ocean waters; only the slow and unpretending, but sure and powerful, action of nature herself could help us to make this important discovery, upon which, as we all know, the existence of the photographic art is almost exclusively based. Iodine and bromine are as necessary for the existence of sea-plants as phosphorus and sulphur for the plants of *terra firma*; they search for it in the waters of the ocean with avidity, and transform it into a solid ingredient of their body, their affinity for these two substances being a very strong and close one. In remote times the ashes of certain seaweeds, already known under the name of varec,* were utilized for the production of soda. The ashes used to be leached with water, the soda being gained from the lye by the process of crystallization. The residuum which produced no more crystals of soda was thrown away, as it was thought to be of no value. But it is just this residuum in which we find the iodine; if we add to it a few drops of sulphuric acid, it is liberated as a violet-blue vapor. Thus we see that these humble seaweeds take upon themselves nearly all the work of the fabrication of iodine; they spare us the enormous task of distillling the salt water, and offer it to us a thousand-fold concentrated, and fit for further manipulation, in their ashes. The same may be said of the bromine which is always found combined with the iodine, and is easily separated from it. It was discovered in the year 1826 in the ashes of seaweed grown in the Mediterranean.

It would not be difficult to give other examples of chemical reactions, and their influence upon our modern industry. The mysterious process of germination, which changes amylum (starch flour) into sugar, and without which the brewing of beer would be an impossibility, and the transformation of vegetable acid into sugar which takes place in ripening fruits under the influence of heat and sunshine, need only to be mentioned to convince us that the modest activity of the vegetable world has been hitherto underestimated. It gives us, in reality, most powerful aid in the attainment of various results which we could never secure by ourselves, however far the development of our chemical knowledge and our investigations in the elements of surrounding things might carry us. It can not be doubted that much is still to be done in this direction, and that the soil which protects from our searching eyes the secrets and mysteries of nature's living laboratory (as such we ought to consider every living animal or vegetable organism) is only drawn aside at one small corner. Our knowledge of organic chemistry is as yet far inferior—in spite of the innumerable discoveries of the last fifty years, to which Liebig's example has led the way—to our knowledge in the science of organic matter.

CURIOUS FACTS ABOUT COLOR.

If we pass to another order of speculations, we can not doubt that the different taste, smell, and color, which characterize leaves, blossoms, and fruits, in million-fold variation, are due simply to chemical operations, the nature of of which, we must confess, are as yet utterly unknown to us. One mineral substance, chromium,* is known to us as the source of a nearly inexhaustible number of tints and colors of every description; but its scale, rich as it is, seems to be infinitesimally restrained when we compare it to the hundreds and thousands of brilliant colors with which even the poorest vegetation covers the surface of the earth!

We must not forget that a color is unreal; it is not a corporeal, palpable substance, but merely a state or condition, which affects our eye in a certain way; it does not exist, but is represented to us by the variable decomposition of the light, as the surface of bodies throws back or reflects only a portion of its rays, and absorbs the rest of them. For instance, we call a body the surface of which absorbs every other ray of the light, and allows only the blue one to meet our eye, blue. The surest proof of the assertion that no real or corporeal color exists—that the colors are, as Goethe calls them, "deeds or children of the light"—must be found in the fact that some persons can not perceive colors which others see distinctly; and that the colors entirly depend upon the manner in which the light is thrown upon them. Dyed cloth and even natural flowers often show, under artificial light, another color than that shown by day. An intensely yellow flame, such as is produced bythe burning of soda salts, makes red substances, such as crimson or cinnibar, appear colorless; and red solutions, looked at under this light, seem to be as clear and transparent as pure water. Moreover, it is quite certain that the form of a substance greatly influences its color. Almost every color gains by fine pulverization. Thus a solid piece of cinnibar is not red, as cinnibar powder appears to our eyes, but dark brown, and the the color becomes proportionally brighter according to the degree of pulverization. Oxide of mercury, the crystals of which are of a shining red color, becomes orange-yellow during the process of pulverization. On the contrary, dark blue smalt† can be changed into a colorless powder by long-continued pulverization and trituration.

But chemical action produces no more remarkable influence upon the color of a given substance than by the physical changes which it causes. As far as minerals are concerned, we are able to follow the reactions which appear to be the cause of a transformation of the color; we know exactly what takes place when white chloride of silver is blackened by the influence of the sun; we can give a chemical explanation of the change of colorless indigo into colored indigo. But the chemical transformations in the bodies of living plants, by which the most manifold and brilliant colors are produced, are almost entirely unknown to us. We see a flower pass through the entire scale of red, from the softest pink to the darkest purple-brown, but can given no explanation whatever of the mysterious process. We know, for instance, that the light of the sun greatly influences the color of living plants, and experience has taught us that, in most cases, its total exclusion is equivalent to the absence of every color; in other words, that it produces white leaves and blossoms. However, this rule is by no means without exception, as many roots, the roots of alcanna,‡ for instance, although buried in the soil and completely secluded from the rays of the sun, possess a strong and vivid color. We can explain neither the rule nor the exception; on the contrary, we know that, as far as lifeless matter is concerned, mineral or vegetable colors are weakened, and gradually destroyed, rather than enhanced, by the action of the light. Our ignorance in this respect, restricts our influence upon the coloration of flowers and blossoms, to a very modest and merely empirical one. A mere chance has led to the discovery that the infusion of sulphates of iron into the soil darkens the hue of certain plants which contain a considerable quantity of tannin; and the gardeners have profited by this discovery for the culture of the hortensia. But these exam ples are rare; and as yet we must renounce all claim to the control and influence of the natural course of things in this field. We may be able to change the color of a plant or flower by transferring it to another soil, but we are never sure of the result, and can not give any scientific explanation of it.

FRAGRANCE PRODUCED BY CHEMICAL ACTION.

The fragrance of a flower is likewise produced by chemical action which hitherto has escaped our closest investigations; we see the result; we see that a flower, like the bee which transforms pollen into honey and wax, fabricates volatile oils out of air, water, and light; but the chemical process itself, is a complete mystery to us. We only know that the slowness or rapidity of the evaporation of these oils is the cause of the stronger or weaker odor of the flower. The mode of their formation is a good example of the unlimited variability and manifold variety of vegetation's chemical powers. Many plants do not limit themselves to the formation of a certain volatile oil in their blossoms or flowers, but produce, at the same time,various kinds of oils in their different parts. The orange-tree, for instance, produces volatile oils in the leaves, flowers, and the rind of its fruit. A close investigation convinces us that these differ, not only in their smell and tarte, but also in their weight, density, and other physical and chemical qualities; that, in short, they are different and independent substances which can not be mistaken for each other. The same plant must therefore possess three different organisms, by which it generates three entirely different substances out of the same ingredients. What chemical laboratory, be it ever so well furnished and skillfully managed, can boast of results in any respect so wonderful? And when will the time come when we may surprise even these mysteries of nature's slow and patient but mighty working, perceive their results, explain their causes, and—if possible, by our own appliances—repeat and renew the wonders of the Creation?

ACTION OF FUMING SULPHURIC ACID UPON THE CARBIDES OF HYDROGEN.—M. BERTHELOT.—The author remarks that the action of sulphuric acid upon organic compounds gives rise to five principal phenomena; that is to say, combination of the acid with the organic matter; dehydration or consecutively hydration of the organic matter; its polymeric condensation; and, finally, its profound destruction, with liberation of sulphurous acid. Without stopping to consider the last result, which is generally complicated with the four others, he examines the evolution of heat corresponding to the former.

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* Incinerated (burned) seaweed.

* Also called Chrome; from χρῶμα, the Greek equivalant for the word color.—[Ed. Int. Rev.]

† Common glass, tinged deep blue, pulverized, and used as a pigment in certain arts.—[Ed. Int. Rev.]

‡ Also called Henna, or Hinna. A shrub of the genus *Lawsonia* (*L. Alba*) which yields an orange-colored dye.—[Ed. Int. Rev.]

FEED-WATER HEATER AT THE EXHIBITION.

IN boiler-houses Nos. one three, and four a very excellent and in some respects quite novel form of feed-water heater will be used, designed by William L. D. Norton, formerly Superintendent of Machinery at the Cincinnati Exhibitions, and now engineer in charge of all steam-generating apparatus under the Chief of the Centennial Bureau of Machinery.

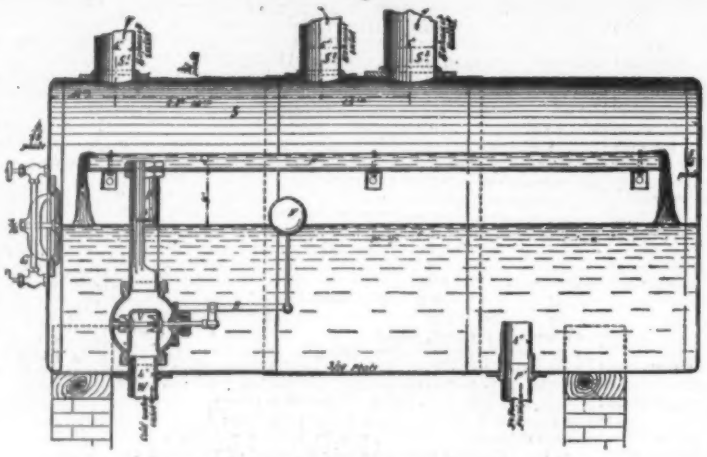
The plan herewith shows a longitudinal vertical section of the inner construction. The water enters from the presure-mains at W, and passes thence through the double balanced cylinder-valve V and vertical-pipe P to the disributing-pan *p*, overflowing at its four sides and falling in a thin sheet to the bottom of the cylindrical shell S, and presenting a large surface for contact with the entering steam. A float F operates the bell-crank B to open or close the valve V and thus preserve a uniform level of water, which level is indicated in the usual manner by the glass gauge G. The pipe P^1 leads to the feed-pump, situated below the level of the heater, which feeds the heated water to the boilers as required. S^1 and S^2 are the terminations of the exhaust-pipes from the engines, and S^3 is the outlet for air and uncondensed vapor from the heater. It is placed adjacent to the chimney in each case, and into which the pipe S^3 is led. With this arrangement the discharge of steam into the atmosphere from the almost innumerable exhaust-pipes of the various steam-using motors is avoided—a very objectionable feature in most of our local exhibitions.

By this method, too, the back pressure upon the engines will be something less: that due to the partial vacuum in the chimney at the point at which the pipe S^3 enters it; this added to the absence of tubes, through or about which steam and water are obliged to circulate in all tubular forms of heaters, must, even for equal temperature of feed-water, make this a considerable economizer of fuel. In boiler-house No. 2 (the Corliss) there will be no feed-heater used, the boilers being fed from the hot-well of the large condensing-engines.

There is still a plentiful lack of energy on the part of exhibitors in bringing forward and placing their exhibits, so large a number of which in the machinery department requiring a long time to perfect them ready for exhibition, and the management are getting more than impatient at the unreasonable delay.

J. T. H.

Fig. 2



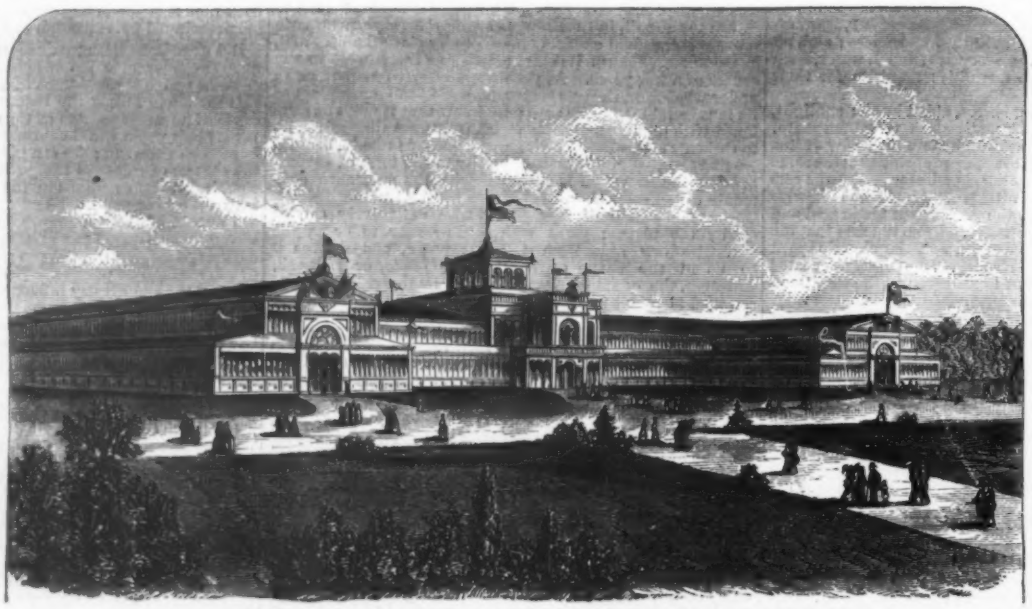
THE INTERNATIONAL EXHIBITION OF 1876.—FEED-WATER HEATER.

THE LONGEST SUSPENSION-BRIDGE IN THE WORLD.

CHARLES J. PUSEY, President of the H. S. B. & N. E. R. Co., sailed for England last week to complete negotiations for building this bridge and its railroad connections. The contract for building the bridge has been awarded to the Keystone Bridge Company, and it is stated that work will begin in the early spring. The plans and estimates by Gen. E. W. Serrell, the engineer, have been submitted to a board consisting of General Q. A. Gilmore, John L. Newton, Chas. B. Stuart, and Jos. M. Wilson, and approved. The bridge will extend from old Fort Clinton on the west to Anthony's Nose on the east side of the Hudson, with a span of 1630 feet between the piers, which is the longest span of any bridge in the world. The span of the suspension-bridge over the East River between New-York and Brooklyn is to be 1600 ft.

The general plan (as taken from the specifications) is a suspended girder, with parallel and cradled cables, and two decks, one upon and one within the girder. There will be a great girder of wrought iron, 1680 feet long, carried by wrought iron towers and cables of steel links and pins. Every possible precaution is to be taken in the manufacture of the steel to produce strength, toughness, and uniformity of texture. The specifications state that each link when finished will be subjected to a strain, by actual force, equal to 20,000 pounds to every square inch of section; the steel used in the links and pins shall have a limit of elasticity, without set, of at least 40,000 pounds to the square inch of section of the original area, and a final breaking strength of at least 80,000 to the square inch. The figure of the pins will be a true cylinder from end to end, between the head and nut. The links near the middle of the span will be about 25 feet long between the centres of the eyes, and so much longer between the centres of the eyes toward the towers that the horizontal distance between the eyes when in position will be 25 feet; the sectional area of the largest links, in the middle of the link, is not intended to be more than 8 inches. The towers will be of wrought iron to the height of the track of the railroad, which is to be 190 feet above high water; above the tracks are to be eight columns, 11 feet in diameter and 80 feet high. In the saddle-chamber in the pediment of each tower there are to be 12 saddles and 2 pairs of compensating levers. All the saddles and levers for the stay system and their attachments are to be carried upon one large frame, that extends across the saddle-chambers in both directions and over the heads of all the eight columns of the towers. The various parts of the saddles and the attachments for the levers of the stay system will all be worked in together on the frame above described. All these parts will move together, enough to compensate the expansion and contraction of the main back-stays that is not taken up by the tower itself. The motions of the saddles will be made upon steel rollers under the carrying-frame, between steel faces. The cables are to be anchored at either end in the solid rock. There is to be a double-track railway on the upper deck of the bridge, and a carriage-way of 16 feet clear width on the lower deck.

The report of the Board of Engineers states that the bridge, constructed in accordance with the design and specifications, will be permanent and durable, and will possess sufficient strength for the purpose intended.



THE INTERNATIONAL EXHIBITION OF 1876.—THE BREWERS' BUILDING.

THE BREWERS' BUILDING AT THE CENTENNIAL.

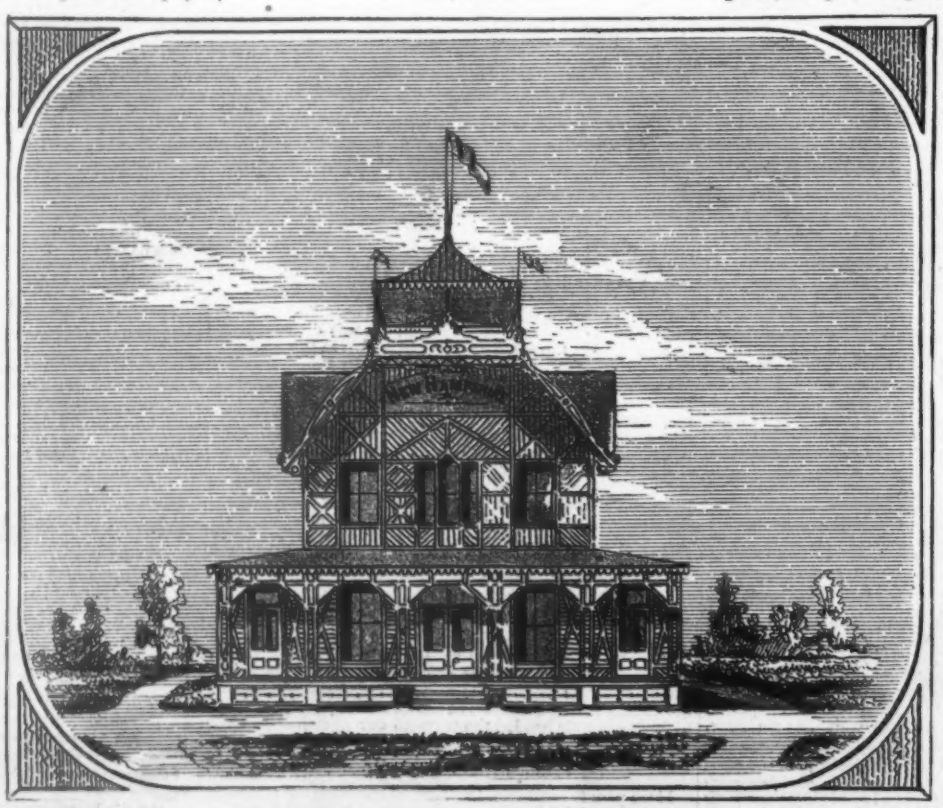
THE United States Brewers' Association, H. H. Rueter, President, Boston, Mass., are to make a grand display at the Centennial, in which all the materials and processes employed in the brewing of beer will be exhibited in full operation. For this purpose the large and elegant building represented in our engraving is erected by the Association, at an expense of $70,000. We are indebted to the *Brewers' Gazette* for our engraving.

The building is 300 ft. in length and 100 ft. wide, and presents a very ornamental appearance.

The brewers claim that the industry in which they are engaged is hampered and imperiled by the popular prejudice which exists against the use of distilled liquors. Fermented refreshments like beer, they allege, ought not to be classed with the intoxicating distilled liquors which are productive of such widespread wretchedness. The use of beer they claim to be highly beneficial to mankind, and they intend to prove this by a national exhibit of the most extensive character. Their object is not to induce a man to drink more beer, but to encourage more men to drink beer.

NEW-HAMPSHIRE AT THE CENTENNIAL.

NEW-HAMPSHIRE is to be well represented at the Centennial Exhibition. The Legislature appropriated the sum of $15,000, of which $10,000 is donated or invested in the Centennial capital stock. The balance, $5000, will defray but a small proportion of the expenses, as the State concluded to erect a building at Philadelphia which will cost $3000, and the State committee of five which was appointed, are collecting enough from the different corporations and liberal and public-spirited citizens to cover the extra cost. The building is after the style of an Italian villa, and when completed, as the accompanying illustration from the *Graphic* shows, will make a very handsome and creditable structure. The State Centennial Committee is as follows: Ex-Governor Jas. A. Weston, chairman; Colonel Riddle, agent; L. W. Clarke and J. H. Briggs, of Manchester; E. C. Baker, of Claremont; and M. W. Tappan, of Bradford.

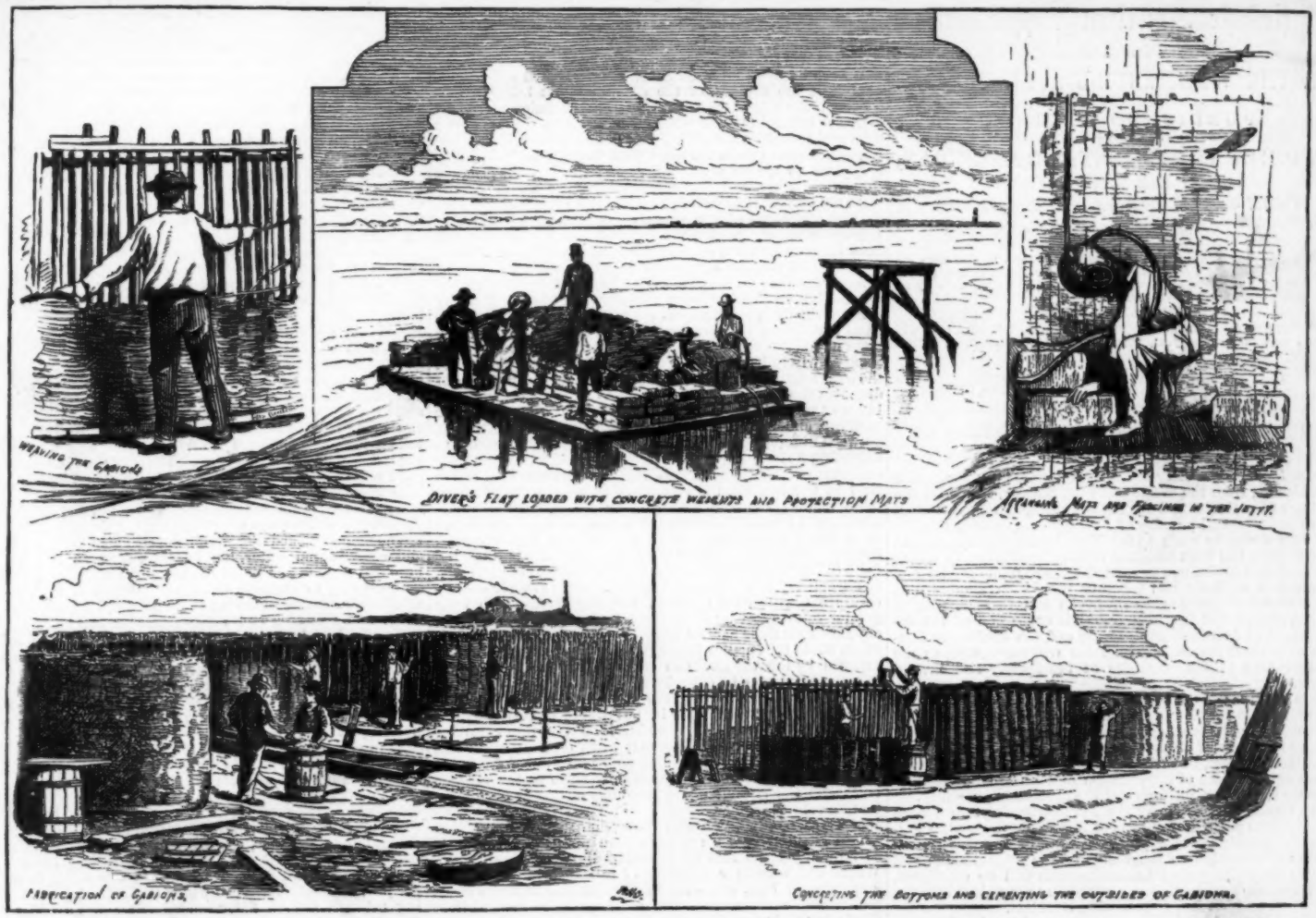


THE INTERNATIONAL EXHIBITION OF 1876.—THE NEW-HAMPSHIRE STATE BUILDING.

USE OF CERIUM FOR ANILINE BLACKS.

IN a communication to the Physical Society of Frankfort-on-the-Main, M. Bottger stated that lately it had been found that cerium, and especially bisulphate of cerium, with the salts of aniline, produces an intense black on cotton yarn and tissues. M. Bottger says that by immersing cotton yarns alternately in a solution of salt of aniline, sharpened with a small quantity of hyrdochloric acid, and in another of bisulphate of cerium, and, finally, in a third solution of bichromate of potassium, a black color of great beauty is obtained.

IT appears that Capt. Webb's swim across the English channel will turn out to be a very profitable job. The testimonial being raised for him has already reached $30,000.


WEAVING THE GABIONS
DIVER'S FLAT LOADED WITH CONCRETE WEIGHTS AND PROTECTION MATS
ATTACHING MATS AND FASCINES TO THE JETTY.
FABRICATION OF GABIONS.
CONCRETING THE BOTTOMS AND CEMENTING THE OUTSIDES OF GABIONS.

THE JETTY WORKS OF GALVESTON HARBOR, TEXAS.

[Daily Graphic.]

GALVESTON HARBOR—PROGRESS OF ITS IMPROVEMENT.

THERE are along the coast many good harbors which are inaccessible to vessels drawing more than a very small depth of water by reason of the sand-bars which obstruct their entrances. The causes which form these bars have long been known to engineers, and with the knowledge of their cause the means of their removal became obvious. But hitherto the expense has been so great as to only justify permanent works where cities of the first class were to be benefited. A bar is caused by the meeting of two currents holding in suspension sand or other earthy matter. A current from the interior of the land, as in the case of a river or bay, is intercepted by a coast current flowing across its path. The velocity of both currents is retarded, and the sand or other matter held in suspension drops to the bottom and the bar is formed. In the improvement of harbor entrances obstructed by bars, the object to be obtained is to provide a sufficient depth of water in the channel across the bar to meet the requirements of commerce. A channel is usually dredged through the bars, or the currents are deflected and trained upon particular points by jetties, so that the volume of water and velocity of the current being increased, the channel will be scoured out and the required depth of water secured. These jetties have hitherto usually been expensive constructions of masonry or of timber loaded with stone. Captain C. W. Howell, of the United States Engineers, suggested a plan of forming jetties by means of gabions made of cane covered with cement and filled with sand. These materials being close at hand and obtainable without cost, he hoped to so reduce the expense of harbor improvements as to render them possible for many places to which they had hitherto been denied. Galveston harbor was selected for the experiment, and the work commenced in September, 1874, under an appropriation of $60,000. The city of Galveston had previously, at an expense of $180,000, made a breakwater of piles driven from ten to fifteen feet into the sand, securely braced and capped. It was found impossible to extend this breakwater, because of the violence of the waves, and the Government determined to make the experiment of Howell's plan at this point. The chances of success seemed to be small, and predictions of failure were freely made by both scientific and practical men, the direct object being to close up certain secondary channels and confine the exit for all the water of Galveston Bay to a narrow path.

The location and form of the jetties were, of course, determined by surveys. It is in the construction and use of gabions that the novelty consists. The work was placed under the charge of Lieutenant James B. Quinn, and has been prosecuted entirely under his supervision. It has proved so successful and so economical that the Board of Engineers have ordered its continuance, and, after further trial, the plan will probably be applied to other localities. The method of constructing these gabions and placing them is this:

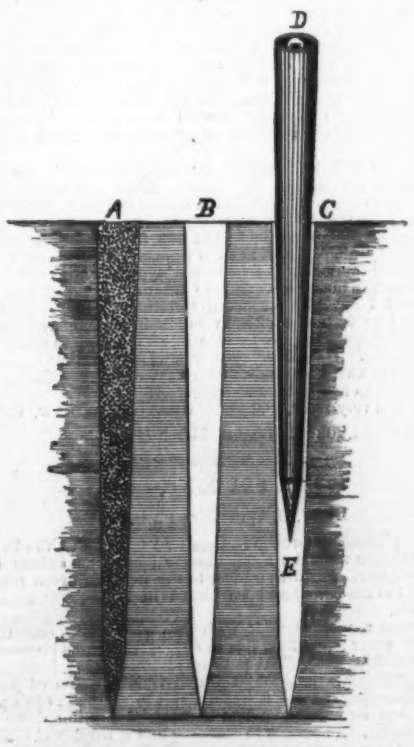
A bottom of two-inch plank is first made; this is taken to the weaving-ground, where the stakes are placed in the holes bored for their reception; a form is fastened at the top of the stakes to hold them in position; the wicker-work is then commenced and carried half-way up, when four cross-braces are fastened in place by galvanized-iron wire; the top form is then removed and the wattling completed; a ballast of concrete is then laid evenly over the bottom, and carefully rammed; a plank top is then put on the gabion and the stakes securely nailed to both top and bottom; two three-quarter iron bolts pass through the top and bottom and bind the whole securely together; the outside is then carefully covered with two coats of cement plaster, after which the gabion is allowed to stand two weeks before it is considered ready for launching.

The stakes are ordinary pine poles, the bark being left on, and the wattling is made with the cane which abounds in this southern country in the greatest profusion, and which for this purpose is far superior to anything yet tried. The cane is deprived of the small branches that grow from each joint. It is then quite pliable and weaves handsomely.

A gabion when finished is 12 feet long, 6 feet wide, and 6 feet high. To prevent the rebounding current from undermining the gabions when placed in the jetties, a mat is made by binding canes, with their small branches left on, to a frame of wood. This is held in place by concrete weights. On account of the foundation upon which the jetty rests being generally uneven, it is not possible to bring the gabions close together at the bottom, about 2 or 3 inches being usually left between them; through this interval the current would rush with sufficient force to excavate a deep hole (sufficient to cause the cylindrical gabions to settle half their height). To close this a short fascine is made of the branches trimmed off the canes, and this is crowded into the interval at the bottom and held in place by a concrete weight.

After the gabions have hardened sufficiently they are mounted on trucks and rolled on board a scow, where they are arranged along the side in position for launching. The scow is then towed out to the place where the gabions are required; a sand-pump placed in a scow occupies a convenient position for filling the gabions. Everything being in readiness, a gabion is launched overboard by elevating the rear end of its truck; it is hauled up alongside the guide-pole, and the flexible discharge-pipe of the sand-pump being placed in the opening left in the cover, the sand is pumped into it until it sinks. If it is in such deep water that the pipe will not reach it, a wooden trough is then placed in the hole in the cover and the discharge-pipe connected to the top of this; the pumping is then continued till the gabion is full of sand. A second one is then launched and filled as before, and so on. The mats and fascines, with the concrete weights, are loaded on a small scow, and as soon as a sufficient number of gabions are filled, the scow is hauled alongside the jetty, and the mats and fascines lowered in about the position required. A submarine diver then descends and adjusts them.

A good test of the permanency of the work was afforded by the late dreadful cyclone which visited the Texas coast, and when the Board of Engineers convened in this city last month, they found their anticipations realized. The entire work had withstood the storm. It is estimated that improvements of this character, by the means of gabions, can be made at a cost of less than $7 per running foot. The photographs of this work were executed by R. B. Talfner, Assistant Engineer, United States Army.



NEW METHOD OF CONSTRUCTING FOUNDATIONS.

NEW METHOD OF CONSTRUCTING FOUNDATIONS.

By O. C. MATTHEWS, Meadville, Pa.

THE object is to construct a solid foundation in soft ground, on which to erect the walls of buildings.

I construct a strong "pile" of iron or of wood, pointed and capped with iron, of the desired size and length to suit the depth of the foundation to be "put down."

This pile is driven in the ground by a pile-driver, and then withdrawn. The hole is then filled with small stone and a "grout" or cement of water-lime and sand is run in, filling the interstices or spaces between the stone. When this has "set" another is sunk by its side, and this process continued until a foundation of the proper length and width is constructed on which to erect the walls of the building.

In driving the pile the soft earth is impacted around the pile, and as one after another of the piles are driven the earth becomes more and more solid, thereby rendering the foundation solid, and capable of sustaining the weight of the superstructure.

D, the pile constructed wedge-shaped, so as to be easily removed from the hole; E, the bottom of the hole as the pile is removed; B, the hole with the pile removed; A, the hol filled with fragments of stone ready to receive the grout o cement.

CERTAIN NEW DERIVATIVES OF ANETHOL.—M. F. LANDOLPH.—The author examines the reaction of alcoholic potassa upon the hydride of anethol; of perchloride of phosphorus upon anethol; of alcoholic potassa upon monochlorinized anethol; and of acetic ether upon diphenol.

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AMERICAN SOCIETY OF CIVIL ENGINEERS AT THE CENTENNIAL.

THE American Society of Civil Engineers has appointed a Commission, from the members of the Society, to aid in obtaining at the Centennial Exposition a proper representation of the progress and practice of American engineering.

A very desirable room in the Main Exhibition Building at Philadelphia has been assigned to the Commission, in which it is proposed to arrange models, drawings, photographs and descriptions of the same, together with such manuscripts, manufacturers' and engineers' books and records, printed matter, etc., as will furnish a complete exposition of the development of American engineering and the distinctive features of present practice. The room will serve, also, as the head-quarters of the members of the Society and invited guests.

It is proposed to have a secretary in attendance, to give information in relation to the exhibits in charge of the Commission, and objects of interest in the general Exhibition also, as to means of access to engineering structures, large manufactures, etc., in various parts of the country, and thus serves as a medium of introduction and intercommunication between exhibitors, visitors, and the profession generally.

The Commission proposes to aid in distributing information in relation to particular objects of interest in the main Exhibition by permitting cards to be affixed thereto, referring for further information to the rooms of the Commission; and albums illustrating special manufactures will be circulated, when the same are sufficiently complete to be valuable to the profession and not mere advertising circulars.

With a view of furthering the objects of the Commission, various sub-committees have been appointed, each to take charge of a special topic, make arrangements for its proper representation, and prepare a memoir in relation thereto.

This portion of the Exposition will comprise:—Turbines and other Water wheels; Hydraulic Engines; Hydrostatic Presses, and adaptations of same for various purposes; Hydraulic Testing and Weighing Machines; Hydraulic Jacks, Cranes, and Elevators; Hydraulic Valves; Pumping-engines; Pumps; centrifugal, rotative, and reciprocating, operated directly by steam, or indirectly from any prime mover, and used for drainage, for high lifts, or great pressures for water, holding in suspension or transporting gritty and other materials; for oils, pulp, and semi-fluids, and those adapted for particular locations or uses; Fire-engines; Water-meters; and in general any apparatus which may properly be classed as Hydraulic Machinery.

It should be understood that the Exposition does not relate to simple inventions, but to apparatus which have actually been constructed and put in public and useful operation.

It is desired to obtain:

1. Information as to decided advances which have been made in relation to any branch of the general subject, with accurate details of the nature of the developments or improvements and models, drawings, photographs, or prints illustrating so far as possible the successive stages of development.

2. Models, drawings, photographs, cuts, and written or printed descriptions of interesting hydraulic apparatus now in use in this country.

3. Authentic records of the performance of hydraulic apparatus, and particularly of careful tests of pumping-engines, turbines, and the like; the records to completely illustrate the construction of the apparatus and give the full details of the trials.

Persons who have made collection of data of this character are requested to loan the same, or furnish copies thereof, for the general information of the profession, through the Commission.

4. Models of machines and apparatus illustrating special manufactures of interest to the profession, which will be received if constructed with neatness and taste, with addresses marked in a plain and simple manner.

Information is requested as to any historic machines which can be procured, for exhibition in some part of the ground under the direction of the Commission.

As the Exposition will be entirely voluntary, and funds for establishing the same derived from contributions, it is desirable that all exhibits should be submitted in proper shape for immediate erection and examination without liability to injury.

Circulars and information may be obtained by addressing the Secretary of the Centennial Commission of the Society, No. 4 East 23d Street, New-York.

ON THE DEEPENING OF THE BEDS OF RIVERS.

TO THE EDITOR OF THE SCIENTIFIC AMERICAN:

Having long given my attention to the subject of the deposition of alluvium and the formation of bars, mainly with reference to the formation or improvement of harbors on sandy coasts, I have read with great interest the able article of Captain Eads in No. 11 of your "Supplement." My personal experience has as yet been confined to the coasts and streams on the German Ocean and the Bay of Fundy, and though I have visited the Upper Mississippi, I regret not having yet had an opportunity of examining the lower and more interesting portion. I had last year prepared the outline of a plan for improving the outlets of that river, subject, of course, to a future examination of the locality, when I learnt that I had been forestalled by the able engineer who is now executing the work. The general plan of his work (I have seen no details), except in some points to which I will not here allude, so much resembled my own, and its basis of principle was so nearly identical, that, hearing of the opposition it had met in high quarters, I have looked with eagerness for some account of the discussion, not being in possession of the official reports. The communication above referred to is the first authentic statement I have seen on either side, and I would not at this time trouble you with this letter, agreeing as I do in the main with Captain Eads, but that it appears to me his article offers in some respects grounds for criticism.

As my imperfect knowledge of the site may possibly lead me into occasional misconception of Captain Eads's meaning, I propose merely to give the general views I have formed from my experience in similar places, and leave your readers to judge how far they agree with his argument.

Absolute relation between volume and velocity has not, to my mind, been clearly shown. In any river unobstructed by shifting shoals, if we leave out all tributaries or effluents, we have a constant volume flowing from source to mouth, the same number of cubic feet passing at every point in a given time, slowly in large cross-sections and rapidly in small, and the effect of affluents or effluents is merely to increase or diminish the volume in proportion. Clearly, then, any variability of volume must be due to newly-formed obstructions or outflows, and must correct itself; for no disparity in volume between different parts of a river can permanently exist. In ascending a river, as each tributary is passed a less volume is encountered, but though, from the usually increasing rise of land in the interior, the stream is commonly found to be more rapid, yet it is not always so; for where the soil is friable, and level stretches occur, floods may so widen its bed as to make its velocity even less than that below the affluent. The facts exhibited by the several passes of the delta differ in their causes from those of the rest of the river, as an entirely new element is added. Here at their mouths occurs a contest with the sea: the large passes with their greater volume forcing themselves further into the sea and depositing on their neutral borders the larger mass of sediment, while the smaller passes, with lesser volume, are sooner arrested by the waves. The effect of closing all the passes but one would be to extend the remaining one at an increased rate in proportion to the greater volume and quantity of sediment carried with it, but would scarcely of itself tend much to lower the flood-level on the upper levees, though it would tend to preserve it when once attained: this can only be effected by providing sufficient area of section in the river itself to contain the flood-volume at the reduced level, but the closing of outlets must obviously be limited by the volume to be received. With regard to the suspension of sediment the terms "overcharged" and "undercharged," used by both parties, give a false idea of facts as they imply the idea of saturation instead of suspension. Water will contain a quantity of salt in solution without increasing in bulk and without precipitation, but the finest particles of sediment are still too large to be held without displacing their own bulk of water, and too heavy to remain in suspension when the agitation that has lifted them has ceased. There can be no overcharge, since water will, under sufficient agitation, take up any amount short of solidity; nor can it be undercharged, since, given sufficient supply, it will hold in suspension a proportion exactly fixed by the amount of agitation and the character of the detritus. Should a stream charged with sediment suddenly enter a rock-bound channel, though continuing to move at the same rate it will at once begin to deposit, from the tendency of the particles to descend, and this tendency will increase when ever eddies or slacks reduce the agitation. This proposition, to which I know of no exception, seems so evident that I confess to some surprise that Captain Eads should have been called on to defend his statement that a deposit must occur below a crevasse.

The bed of the Mississippi, it would seem, generally presents the phenomenon of a broad space of loose alluvial deposit, which in the lower stages of water is torn into tortuous shifting channels interrupted in places by bars of blue clay. Of course, in floods the highest parts become practically the bottom of the river, and the water rises proportionally on the levees. But though the operation of removing this difficulty may perhaps prove costly, it need surely not be abandoned as a feat beyond the power of an able engineer to accomplish. There must be many spots whose cross-sections would serve as data for their respective reaches, and means can certainly be devised to confine low water to a regular channel while providing sufficient area for floods. The difficulty with clay-bars appears to me, in view of the general magnitude of the undertaking, to be trivial: the dredge can, at any rate, remove it, and blue clay even will not redeposit itself unmixed. Should such a plan be carried out, there certainly would be no necessity for further raising the levees.

The one defect (if such a term may be used) in the plan now being carried out by Captain Eads is, as he acknowledges, that the work will, in the nature of things, have to be resumed in the future, at a certain date calculated from the rate of former advance; but this time will probably be somewhat anticipated, for as the principal pass deepens, the others will diminish, and increased deposit seaward will occur from the main pass. It is to the prevention of this defect that I have been especially giving my attention, and, should I be fortunate enough to obtain the opportunities I desire, I hope before a great while to be able to make my plan public. It will be readily understood that my plan does not in any way conflict with that of Captain Eads, but is rather of a supplementary character.

Yours very truly, GEO. H. HENSHAW, C.E.

STE. ANNE BOUT DE L'ISLE, March 11, 1876.

SEA-COWS.

By W. H. WINSLOW, Ph.D., M.D.

ONE pleasant afternoon in October I went up to the Zoölogical Garden to make some observations upon animal life, and was attracted, with others, to the new Carnivora House, where the sea-cows had been placed in their permanent receptacle.

I found a wooden tank with two glass sides, containing muddy water about four feet in depth, which was impenetrable to curious gaze. The tank was located at the junction of two passage-ways, through which rude currents of people were hurrying, so that it was difficult to maintain one's position; but by bracing against a post and putting down my cane firmly, I succeeded in standing like a coral-reef. Not a line of the creature was to be seen at first, but after getting accustomed to the obscurity, I noticed a crescentic segment of white and dark gray back, a foot long and four inches high, which projected above the surface. After about five minutes the segment settled slowly from view, a narrow rim of nose appeared, the little trap-doors which guarded the nostrils were opened, the animal exhaled and inhaled, the nose went out of sight, and the crescent of back reappeared. This cycle of movements occurred every few minutes during the hour that I watched, and, notwithstanding its aquatic home, this proved it to be incapable of breathing air in water as fish do, an opinion which my knowledge of his lung-structure supported.

After an interval the keeper started a flow of fresh clean water into the tank, and let the muddy water escape, so that the uncouth animal became distinctly visible, and I learned that his *compagnon de voyage* had died some days before, leaving him alone.

Anxious visitors were standing on tiptoe around me, and curious remarks greeted my ears. A fashionable young lady avowed "it would take three silk hats and a cane to help her to see." "That pipe brings in hot water from the boiler," said a verdant youth to his sweetheart. "You know, Malvina, this animal comes from the South, where the sun burns people black and the rivers are steaming hot. That's the reason they put in hot water for him to swim in, and boil the greens before they feed him." An uneasy, nervous man near opened his eyes wide at this, looked intently, and then exclaimed, "See that great dark place with a white rim around? That's his mouth." His timid wife was not tall enough, but I looked sharply, for this was a new anatomical description of the parts. There in the dimness was a good reflection of the open mouth of a German along the line, who was staring with wondering countenance. "It is nothing but a fish," said another man, as he hurried to the open air where smoking was not forbidden.

The animal looked not unlike a fish as he rested quickly and easily in the water, his body forming an arc, and his nose and flippers and broad flat tail just touching the bottom, while, owing to shallow water, the portion of back before mentioned remained uncovered. The flippers moved up and down and forwards and backwards, and the tail described perpendicular curves, which movements forced the animal upwards or downwards and forwards. His movements were measurely slow, but graceful enough—not awkward and cumbersome, as related by some naturalists. He seemed to be enjoying the *otium cum dignitate*, to which he was justly entitled for the perilous voyage from South America which he had just completed.

Around the tank I noticed remnants of the river grasses and cabbage which had been given him, as the only available substitutes for the products of his marine pastures.

In Zoölogical classification the sea-cows belong to the sub-kingdom Vertebrata, class Mammalia, sub-class Monodelphia, order Sirnia, family Manatidæ. This last includes but two species, the *Halicore* and *Manatus australis*. Both of these are called sea-cows. The former have a perpendicular notched tail like a fish, and two tusks in the upper jaw, while the latter, to which the animal I am describing belongs, have a flat, rounded tail and no tusks. The Manatidæ, with the order Pinnipedia, which includes the seal and walrus, have heads and breasts with something like a human resemblance, and imperfect views of them obtained by early and ignorant voyagers gave rise to the wonderful stories of mermaids and mermen which we have all heard in childhood, and of which even the poets have sung.

The whale, porpoise and dolphin, now grouped under the order Cetacea, formerly included the sea-cows, and united they have been called Mutilata; but this is unscientific, because the true Cetaceans have special structures connected with the respiratory organs which adapt them to their aquatic conditions of life.

The *Manatus australis*, or manatee, the proper scientific name for our sea-cows, is, when fully grown, from eight to twenty feet long, and ours therefore were very small specimens, their length being between six and seven feet. The skin is yellowish-white upon the abdomen, gray upon the sides, and dark gray upon the back. It is covered by rough, pointed epidermic scales, set up edgewise, and is thick and tough as sole-leather. At the nostrils it forms disk-like doors the size of a penny, which fit accurately into the openings, free except above, so that they swing as upon hinges. They are raised during respiration and closed so as to perfectly exclude the water when the animal is below the surface. The nostrils are upon the upper anterior portion of the nose. The very small black eyes have narrow eyelids, and are situated above and outside the nasal openings. The ears, upon the side of the head, are mere folds of tissue surrounding the tympanic membrane even with the skin, and a mustache of long stiff hairs points out from each side of the thick upper lip. The rounded head, with its coarse prominences and almost hidden under-jaw, bears a striking resemblance to the muzzle of a pure bull-dog.

The powerful flippers are attached to the thorax a little farther posterior than the pectoral fins of a fish, and are moved by muscles corresponding to those of the human arm. They look like the picked wing of a fowl, but are shorter and broader at the extremities. They are covered by thick skin terminating in four strong talon-like nails. There are no clavicles.

The body in the dorsal region is perpendicularly oval. The tail is flat, broad, with rounded outlines, and resembles a paddle. It is composed of fat, muscles, and skin. The latter is here very thick, tuberculated, and fissured. The vertebræ do not extend into it, and it is therefore very flexible. As the pelvis and posterior limbs are absent, it receives a great muscular supply which adapts it to support and motion in swimming. There are no gill openings, as so many suppose, because the animal can not breath air through the medium of water as fish do. The females have thoracic mammæ, and suckle their young. Our specimens were males, and it seemed a little inappropriate to call them sea-cows. The name was applied to the family because they feed upon grasses.

The heavy jaws contain no incisor teeth in adult life, but a row of huge grinders (molars), eight upon each side above and the same number below, show that they belong to the Herbivora. The tongue is short and roughened to serve for prehension in securing their slimy food. The heart has four cavities, as in all mammals, and the ventricles separate at the lower part, forming two apices. The arteries of the neck spread out in a remarkable manner, and divide into a close network, which is technically called a *rete mirable*.

The lungs are about two feet long, very coarsely cellular, and lie upon each side of the spinal column. The intestines are two inches in diameter. A diaphragm placed almost longitudinal separates thorax from abdomen. The sea-cow which died had the intestines stuffed with comminuted green vegetable matter. The other, which has died since my visit, contained many parasites called *Amphistorna*, and presented evidences of inflammation, which was supposed to be due to a

fall in temperature. The other viscera of this strange animal present no peculiar deviations from the typical forms.

These animals became much livelier when muddy water was admitted to the tank than when clear was supplied, the former being more in accord with their natural element. They live upon the grasses which grow in shallow water along the banks of the estuaries of great rivers, and are found upon the coasts of Africa, South America, and Florida, where the currents carry great quantities of vegetable matter far out to sea. They are very numerous about the mouth of the Amazon, and one was recently taken in Indian River, Florida.

When we remember the warm, equable temperature of their tropical home, their abundant supply of fresh and peculiar grasses, their vast range of luxuriant pasture, and the freedom with which they sport in their diluted brine, and consider the great violence done to their economy by subjecting them to artificial water, to different and probably improper food, and to confinement in a place hardly large enough to permit them to turn around, it is not surprising that they die soon.

Natural conditions of life are always modifying the species of animals throughout the world. Those which we know are the resultants of changes effected by natural conditions since creation was accomplished. These mutations are so gradual, and the circumstances which engender them are so various, that we can not trace their steps; yet we see around us an adaptation of animal and vegetable life to the climatic and telluric conditions which we know is not accidental. Any disturbance of this harmony, any transposition of an animal or plant to conditions different from those to which it has been conformed or adapted, is a violation of natural law, which is extremely dangerous to the individual, and generally fatal to the species. Profound modifications must occur or destruction ensue, and the last is usually the rule.

Observation has shown us that the higher the animal the more able is it to withstand such a transposition, so that man, cradled in the lap of Asia, is able to endure the fierce heats of Central Africa or the horrible cold of the polar regions; but the trial is perilous, and should he remain he is soon conquered by adverse circumstances, leaving perhaps a progeny which degenerates ultimately into the stupid and stunted Esquimau or the swarthy and barbarous African.

The human bones which enrich the soil of India, or lie white and shining upon the icy shores and floes of Greenland, are but monuments to nature's law of adaptability. If man perishes thus, is it any wonder that the manatees, low in the class of mammals, should die in their watery pen?

Zoölogical societies are yet in their infancy in this country, but they promise to increase in number and efficiency until, at some not distant period, we shall be able to study at our doors almost the fauna of the world. To the pleasure-seeker they will prove an ever-varying scene of enjoyment, and to the student of zoölogy of inestimable value.

It is to be hoped they will be partly controlled by students of this special branch of science, so that the artificial conditions in which their animals must live may conform as nearly as possible to the natural conditions of life from which they must be violently removed. Thus may be avoided such a laughable mistake as occurred not long since, when a strange mortality in a zoölogical garden led to the discovery that the Carnivora were fed upon vegetable, and the Herbivora upon animal food.

821 SOUTH-TWELFTH STREET, PHILADELPHIA.

THE SAN FRANCISCO FREE BATHS.

THE San Francisco *Call* has the following account of the plans to take advantage of Mr. James Lick's gift of $150,000, to be used in the construction of free public baths in San Francisco: "The building is to be constructed of iron and glass. It is to consist of a hall 370 feet in length by 80 feet in width, with two aisles 17 feet in width; a centre transept 150 long by 70 feet in width, and a transept at each end measuring 110 by 40 feet each. The roof is arched, the elevation of which is 70 feet. In the centre of the building is a dome 130 feet high. In the centre transept are vestibules at each end, which are to be paved with English encaustic tiles, and entrances in the sides of the north and south end transepts, tiled in the same manner. The ticket-office and waiting-rooms will be placed in the vestibule. The interior is divided into three compartments distinct from each other. The middle compartment is to be devoted to men only, the bath in it being 160 feet in length and 50 feet in breadth. The south end will contain the bath for boys, the dimensions of which will be 80 by 50 feet. The bath for ladies will be in the compartment at the north end, and will measure 80 by 30 feet. The swimming-bath for men will be 12 feet deep in the middle, shoaling at the ends to about four feet; the other baths will be from 4 to 5 feet deep. The central tank will also be elevated, the walls surrounding it being strengthened by buttresses. It is designed that the compartments between the buttresses shall be converted into aquaria with thick plate-glass fronts. On the top of the wall of the bath dressing-boxes will be erected for the convenience of bathers, and above that a small gallery for spectators. The bath will be surrounded with walks seventeen feet wide, paved with artificial stone, on the outer side of which tropical plants will flourish, and on the inner side will be the aquaria already mentioned. It is proposed to supply the tanks or bathing-ponds with salt water from the bay. Pipes will be laid from the building to the middle of the bay for that purposes, and an engine will pump the water into the tanks. The water is not to be heated, if possible, by artificial means, but by the employment of the heat of the sun's rays. To accomplish this end, fine jets will ascend to the roof of the building, and fall in almost imperceptible spray into the tank, the sun's rays meantime passing through it and warming it before it reaches the basin. This is the plan adopted at the public baths at Liverpool, England, only the jets do not ascend as high in that establishment as Wright & Sanders intend they shall do in this building. The latter will consequently receive a greater amount of heat, as it will have to pass through a greater area of heat contributing space from the pipe to the tank."

[Pall Mall Gazette.]

CREMATION IN MILAN.

THE Milan newspapers publish detailed accounts of the cremation of the body of Signor Keller. The ceremony appears to have attracted much attention, and a great number of persons were invited to be present. Among those who attended were representatives of the muncipality of Milan, of the provincial and communal sanitary councils, of the learned and scientific professions, together with many distinguished members of Milanese society, and Professors Polli and Clericetti, the inventors of the system of cremation employed. "The crematory chapel," which has been built in the public cemetery out of funds left by Signor Keller for the purpose, is about fifty feet in depth, with a frontage of about forty feet, in the Doric style of architecture, and, being raised about three feet above the level of the cemetery, is approached by steps.

In shape it consists of two distinct but connected parts. The first and main part, which is a perfect square, is supported at each angle by pierced pilasters, between which, at the back and front of the building, stand two columns. The second portion is divided into two semicircular parts, each of which is supported by six columns. In the centre is placed the urn for cremation. Behind the chapel rises a boundary-wall in such a way as to conceal an apparatus for manufacturing gas; and in connection with this is a tower about thirty feet high, which hides a chimney so arranged as to carry off the smoke of the gas apparatus, and, by means of pipes connected with the urn, the gases given off by the body in the process of cremation. Over the principal front of the chapel is the inscription: "Temple for cremation, erected at the wish of Alberto Keller, and given by his heirs to the commune of Milan."

To this chapel, on the 22d of January—the first anniversary of his death—was brought the body of Signor Alberto Keller, in compliance with his will, for cremation. The coffin, having been opened at one end, was placed near the urn, above which a flame was playing, and then by some unseen contrivance the body was conveyed inside the urn, and submitted to the action of the fire.

Signor Pera, the Protestant minister, clothed in a black cloak and black cap, pronounced a discourse in French, commending the example set by Signor Keller, and contending that neither in religion nor good feeling was there any thing opposed to the practice of cremation. He was followed by three other speakers—Professor Clericetti, who expounded his system; and Professor Poletti, of the University of Padua, and Dr. Pini, who spoke of cremation as a step in advance in the path of humanity, and as a practice sanctioned by civilized peoples, international congresses, and political and scientific writers.

Meanwhile, by looking through an aperture in the urn the persons present could see the body in process of cremation. It rested upon a kind of gridiron surrounded by flames given off from two hundred and seventeen jets of gas; beneath was placed a receptacle to catch the ashes as they fell. To a person merely looking on, nothing was visible of the process but the bright flame which burned steadily over the urn, and a dense column of smoke which escaped from the tower. The ceremony lasted about an hour and a half, at the end of which time the urn was opened, and the body was found completely calcined. During cremation no offensive smell was perceived. It is, however, hoped that the system will be shortly improved, so as to produce a more complete incineration.

[Norfolk (Va.) Landmark.]

REMARKABLE BLOW BY A SWORDFISH.

THE brig P. M. Tinker, Captain Bernard, previously mentioned as having arrived here from Richmond, leaking, for repairs, has been hauled up on the ways at Graves' shipyard. On examination, it was discovered that the leak was caused by a swordfish, the sword being found broken off forward the bands, about sixteen feet abaft the forefoot. The fish, in striking the vessel, must have come with great force, as the sword penetrated the copper sheathing, a four-inch birch plank, and through the timbers about six inches—in all about ten inches. It occurred on the morning of the 23d of December, when the brig was eighteen days out from Rio, and in the neighborhood of Cape St. Roque. She was pumped about 4 o'clock in the morning, and found free of water. About 6 o'clock the same morning she was again pumped, when water was obtained, and on examination it was found that she had made ten inches of water. The men were kept steady at the pumps until her arrival at Richmond, and while there and on her trip here.

[Bulletin U. S. Geol. and Geog. Survey.]

THE LARGEST GONIATITE IN THE WORLD.

By F. B. MEEK.

MY attention was recently called by Mr. Stevenson, of Dr. Hayden's United States Geological Survey of the Territories, to a ponderous, irregular mass of hard limestone that had been shipped to General Charles Ewing, from Osage, Eastern Kansas, by the Rev. Paul Ponziglione, of the Osage mission. It contained shells of *Spirifer cameratus*, *Athyris subtilita*, and other forms common in the upper beds of the Coal-Measures of that region; but the object that had attracted special attention was a brownish, smooth, oval subglobose body, exposed on one side by breaking the mass from the parent rock.

At a first glance, this oval body seemed to present a startling resemblance to the upper surface of a large human skull. On a closer examination, however, although sutures were visible in it, they were seen to be very different from those of the human cranium. In other words, they were found to be the septal sutures of a gigantic shell of the genus *Goniatites*. As thus seen partly exposed, this shell measured six inches in breadth or convexity by about nine inches in its greater diameter. On breaking away portions of the enveloping rock, however, it soon became evident that there was still another volution outside of that first seen, thus increasing the convexity to about nine inches, and the greater diameter to about eleven inches. Yet this outer volution is septate as far as it can be traced in the rock; and as there must have been at least one half of another turn, and possibly more, to form the outer non-septate chamber for the reception of the animal, I think we may safely infer that the greater diameter of this shell, when entire, must have been about sixteen inches, and possibly more. So far as I can remember, this would therefore be one of the largest, if not the largest, species of the genus *Goniatites* ever discovered. *G. Marcellensis* and some other species are said to have attained to the dimensions of twelve inches in their greater diameter; but these are discoid, and not subglobose shells, and consequently their convexity and entire volume are much less than the shell here under consideration.

So far as I have been able to determine, this shell agrees well in its septa and form with a large *Goniatite* from Kansas, figured by Mr. Worthen and the writer on page 390 of the second volume of the Illinois Geological Reports, and there referred to *G. globulosus*, M. & W. The type-specimens of that species were found in the Upper Coal-Measure near Springfield, Ill., and seem, so far as I am aware, rarely if ever to attain there a size of more than about one to two and one-fourth inches in their greater diameter.

The Kansas shell mentioned above and that here under consideration both agree very closely in form and their septa with the Illinois species; but, although mere differences of size are not generally reliable characters for the separation of species, the question naturally suggests itself whether shells differing so *extremely* in size (the large being found in one district and the small in another) are really specifically the same? Although not fully satisfied that this may not be the case, it seems to me desirable that this huge Kansas shell should be at least viewed as belonging to a distinct variety. Consequently I would propose to designate it as *G. globulosus* var. *excelsus*.

[Engineering and Mining Journal.]

COMPOSITION AND TRANSPORTATION OF NATURAL GAS.

THE following analyses of natural gas from the Burns, Leechburg, and Harvey gas-wells, in Pennsylvania, were made recently by Prof. S. P. Sadtler, of the University of Pennsylvania:

	Burns Well.	Leechburg Well.	Harvey Well.
Carbonic Acid	.34	.35	.66
Carbonic Oxide	trace	.26	trace
Illuminating Hydro-Carbons	....	.56	....
Hydrogen	6.10	4.79	13.50
Marsh-gas ($C H_4$)	75.44	89.65	80.11
Ethyl-hydride ($C_2 H_6$)	18.12	4.39	5.72
Propyl-hydride ($C_3 H_8$)	trace	trace	trace
Oxygen	....	....	....
Nitrogen	....	....	....
	100.00	100.00	99.99
Specific Gravity	.6148	.5580	.5119
Calorific Power (Cent. Units)	14.211	14.105	15.597
Calorific Intensity (theoretical temperature attainable by combustion in air) (Cent. degrees)	2745°	2746°	2763°

The satisfactory results obtained in the use of natural gas in several of the Western Pennsylvania works—from Erie to Pittsburgh—have been frequently recorded in these pages.

The partial failure, in carrying it through 18½ miles of pipe to Messrs. Spang, Chalfant & Co.'s mill, in Pittsburgh, has not disheartened those interested in iron-works there, and, in fact, the difficulty, which was the low pressure at which the gas was discharged at Pittsburgh, suggested the natural and only effective remedy for the trouble—namely, larger pipes and fewer angles in them.

The remarks we have since heard, that a higher pressure would be obtained by putting a reservoir at the discharge end of the pipe, seemed so ridiculous that we did not suppose it would be seriously entertained; yet the following editorial note, from the *American Manufacturer*, indicates that the same idea still seems to inspire the Natural Gas Company. The italics are ours:

"Messrs. Kirk & Dilworth have succeeded in organizing a strong stock company to bring the gas from the Burns and Delamater wells, in Butler County, Pa., to Pittsburgh. The capital is put at $500,000, and will be taken mostly by our manufacturers, Andrew Carnegie being one of the principal stockholders. The distance to be piped is 35 miles, and 6, 8, and 10 inch pipe will be used, *the smaller pipe at the wells, and the 10-inch at the delivery terminus*. Experts claim that the gas of each well is equivalent to 50,000 bushels of coal per day, and experience shows that less than ¼ is lost in transportation for the distance named. This estimate, of course, is in part conjecture, as there have not yet been found instruments to measure so large a flow of gas."

We would suggest, as an excellent preliminary investment for the new company, a little engineering skill to direct their counsels—and if that be a rare commodity in Pittsburgh, let the managers spend a few minutes in considering the effect on the pressure at the delivery end of a garden hose, of putting the nozzle at the faucet from which the water is taken, and leaving the hose open to its full size at the other end. This little experiment, which must be familiar to most of them, would indicate that they are getting things "wrong end foremost" in their pipe line. Would it not be wiser to make their smallest pipe at least 12 inches in diameter, that they may not find the supply limited when their work is done?

The remarks about the value of the gas in tons of coal are, we need scarcely say, of the wildest, and the estimated loss in transportation is also a mere guess; experience has shown a much greater loss in the case referred to.

VOLUMETRIC DETERMINATION OF ORCINE.

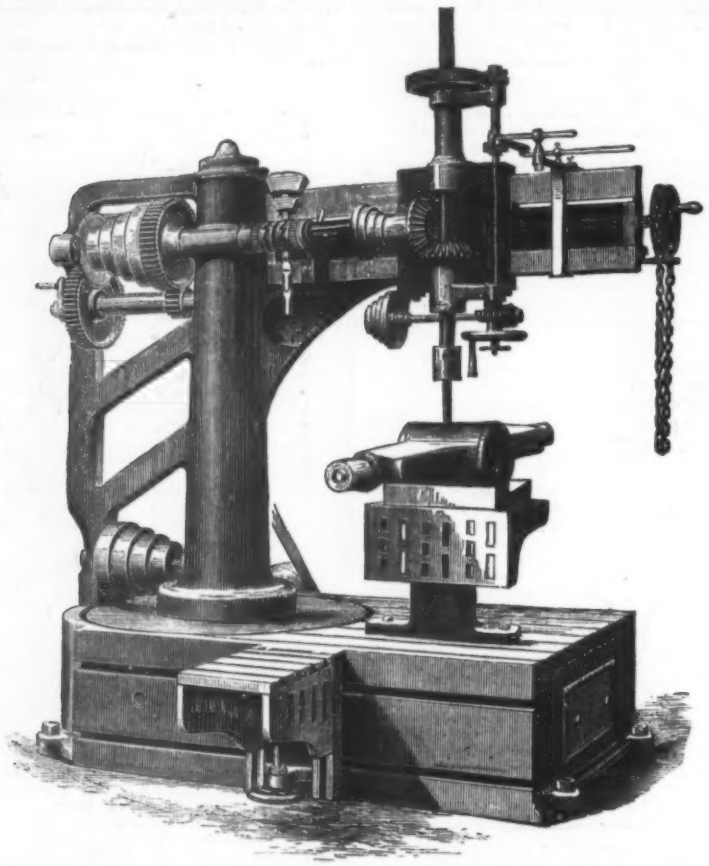
By M. S. REYMANN.

THE author proposes to determine orcine in solutions of this body in water by a method depending on the action of bromine upon orcine. It is known that a dilute solution of orcine, if treated with bromine-water, takes a yellow color and forms monobromorcine. If a fresh quantity of bromine-water is added, the precipitate suspended in the liquid takes a transient white tint and then assumes a permanent yellow color, forming tribromorcine. This transformation of orcine into tribromorcine is very well marked and almost perfect. M. Reymann applies this reaction to the determination of orcine. It dissolves absolutely pure orcine in water and adds to this dilute solution bromine-water the strength of which must be deteumined at the instant. He continues the addition of bromine-water till the precipitate takes its final yellow color, and till after being shaken for some minutes in a stoppered bottle the mixture gives off a faint odor of bromine. He adds then a certain quantity of solution of iodide of potassium, and determines the quantity of iodine set at liberty by the excess of bromine by means of hyposulphite of soda. A very simple calculation shows how much bromine has been employed in the formation of tribromorcine, and consequently how much orcine is contained in the liquor.

By treating in this manner the liquid extract prepared with the orchella weeds of commerce we may thus, in the opinion of the author, find their relative value, but as orcine does not always exist ready formed in the weeds, and is only formed at the expense of other constituents during the operation of orchil-making, the process does not give an exact idea of their value. In orchils, etc., it shows the relative amount of orcine present.—*Chemical Review.*

IMPROVED DRILLING AND SLOTTING MACHINE.

IN the accompanying engraving we illustrate a drilling machine made by Messrs. Lowry, of Cross Street Works, Salford, England, which embodies certain improvements introduced recently into this type of drill. These may be briefly described as consisting principally in carrying down the framing at the back of the jib-post to the bed-plate, so that it can be properly secured, and every trace of vibration is removed. The machine has also been so modified that it constitutes a very satisfactory key-way slotting machine. Our engraving, which is from *The Engineer*, will explain itself without further description.



LOWERY & CO.'S DRILLING AND SLOTTING MACHINE.

NEW WATER METER.

THERE are two kinds of water meter, namely, the positive or actual measurer—and the inferential meter. This first is generally formed of a piston and cylinder with the corresponding valve or tap. When in operation the water enters the cylinder at both sides of the piston alternately, and at the same time is expelled by the action of the piston, actuated by the pressure of a head of water. Thus the cylinder is filled and emptied successively and continuously, and the volume swept by the piston at each stroke being known, the quantity passing is recorded on a dial by simple means easily understood. These meters, however, possess the disadvantage of liability to wear and tear in their operation, besides demanding considerable pressure in order to render them effective, which pressure in certain localities is not available.

The inferential meter consists of a small vessel containing a vane or screw fixed on its axle and revolving with freedom in suitable bearings. By the action of the passing water the vane acquires a rotary motion corresponding in speed with the velocity of the passage of the water. The action is similar to that of the patent log, gear work indicating on a dial the quantity of water inferred to have passed. The Deacon water-meter is another example of the inferential system. The rotating instruments are tolerably accurate when the full stream of the pipe supplying them is allowed to flow, but any material departure from this renders the indication erroneous, and by the accumulation of dirt they are sometimes rendered useless.

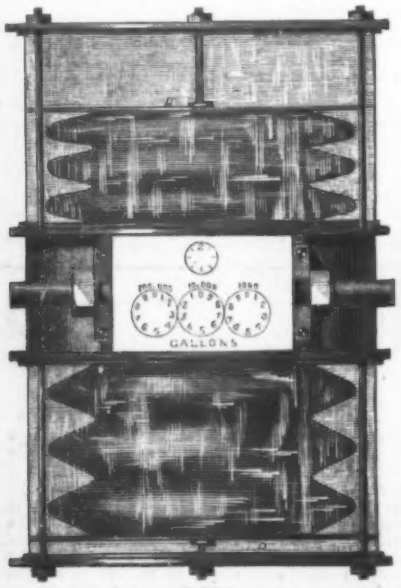


FIG. 1

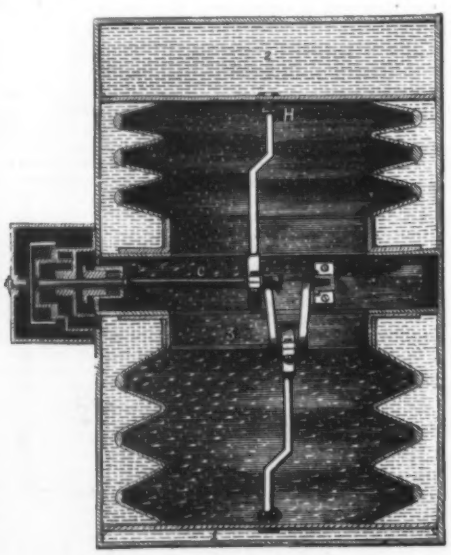


FIG. 2

FIG. 4

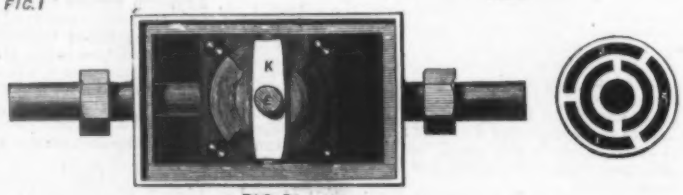


FIG. 5

THE RICHARDS WATER METER.

The meter represented in the engravings is of the positive description—that is, it is an absolute measurer, intended for either high or low pressure, and is the invention of and patented by Mr. William Richards, the inventor of the dry gas-meter. In this, as in the dry gas-meter, the fluid being measured is separated by one or more flexible divisions or diaphragms, answering the purpose of a piston within the cylinder, and separating the measured from the unmeasured water. Within the cylindrical vessel, a portion of which is made of glass for the purpose of showing the action of the meter, Fig. 1, which is closed by a plate at each end, are hermetically attached two flexible diaphragms, each in form resembling the circular forge bellows, which divide the outer case into three distinct compartments or chambers, Nos. 1, 2, and 3, as represented in Fig. 2. To each diaphragm is affixed a disc, which moves freely within the case, and has three or four apertures on its periphery to permit of the water passing with facility into and from the chambers 1 and 2. The diaphragms are of considerably less diameter than the outer case, in order to prevent any rubbing or friction at those parts, and are guided by their discs. A shaft *c* is provided with two cranks placed at an angle of about 120 degrees to each other, and works in a suitable bearing at one end, the other end protruding through a stuffing-box and through the seat of a rotary valve with its cover. To this end of the shaft is attached the carrier *k*, Fig. 5, which gears with the lugs of the cover of the valve. Thus by the rotation of the shaft the cover permits of the ingress and egress of the water into and from the various chambers in succession,

The connecting rods, Fig. 2, are attached to the discs by means of the hinges H H, the stroke of each disc being controlled by the throw of the cranks. Fig. 3 represents a plan of the rotary valve, through the centre orifice of which passes the shaft *c*. The outer ring of the openings communicates with the chambers corresponding with their numbers. The two central spaces are in communication with the outlet. Fig. 4 is the face of the cover of the valve, the opening *i* being the passage of ingress and *o* the outlet; this corresponds with its seat in such a manner, that as the water enters one of the chambers it is also expelled from another. Fig. 5 represents the interior of the square box with the index removed, and shows the carrier K attached to the shaft and gearing with the lugs on the cover of the valve, on the top of which the water to be measured always enters. The action of the meter is as follows: The water enters the small box, Fig. 5, and passes through the valve into one of the chambers, and as represented is passing into that numbered 3, and has depressed the lower disc to the utmost limits, its crank being on the centre and inoperative; but in depressing the disc a quantity of water has been expelled from chamber No. 1 equal to that entering No. 3. The upper disc is rising by the action of the water and expelling a like quantity from chamber No. 2. In the meantime the changed position of the valve and crank permits the water to enter chamber 1 and expel a like volume from that marked 3, until the diaphragms collapse, when the action is reversed. In this manner the diaphragms are distended and collapsed alternately, and the action being continuous, a uniform flow of water is always being received and ejected, therefore, according to the capacity of the diaphragms and the distance they pass through, so will be the quantity delivered at each revolution of the crank, and this determines the necessary wheelwork for the index, and it is claimed that every drop of water passing through the meter is recorded with the most rigid accuracy.

As a precaution against any strain on the diaphragms the valve always has a lead, so that the inlet and outlet of any chamber are closed just before the crank gets on the centre.

The advantages claimed by the inventors are simplicity of construction, and the comparatively low price at which the meters can be manufactured. The friction is so slight that with a column of water only 3 inches in height the instrument is set in action, hence water measured by it will be delivered almost at the same elevation as it is supplied from.—*The Engineer.*

SHAPING MACHINES.

THE "SLOW ADVANCE AND QUICK RETURN" MOTION.

By PROF. C. W. MACCORD.

AN important and interesting practical purpose for which elliptical wheels may be used is the production of the "slow advance and quick return" movement, such as is required in a shaping-machine. Having determined how much more rapid the return is to be than the advance, the next thing is to construct a mechanical movement which will make it so, and there does not seem to be much readily accessible information as to the methods of accomplishing it. We give below three different movements, with explanations of the mode of proportioning the advance to the return in any desired ratio, and also velocity curves for comparing their action, accompanied by a description of their construction. The varying velocity required is obtained in the first movement by a pair of elliptical wheels; in the second by a crank-pin acting upon a slotted lever, and in the third by a crank and connecting-rod actuating a vibrating lever, as in a Monitor engine.

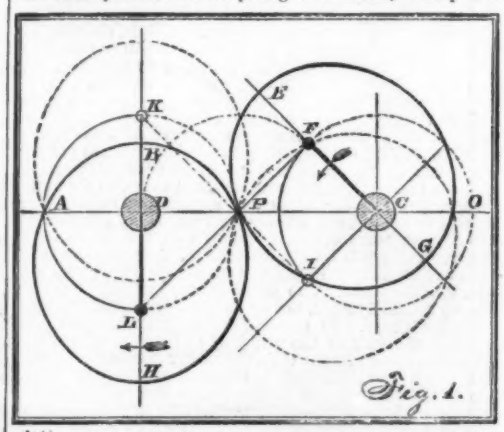
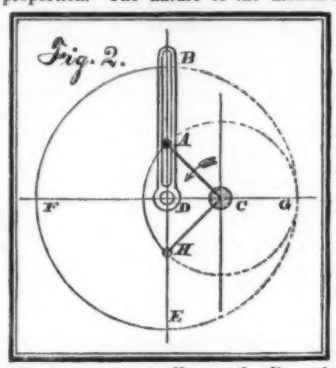


Fig. 1.

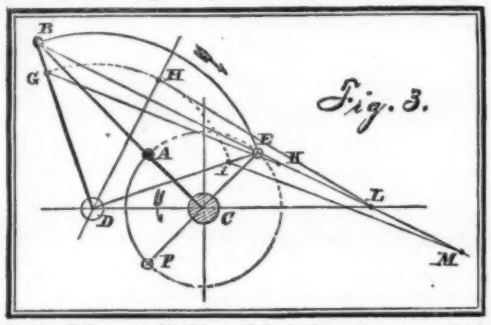
For the purpose of illustration, let us suppose that the advance motion is to occupy three times as long as the return. Then, first, to determine the forms of the ellipses: in Fig. 1 let A C be the line of centres, and C the fixed centre, and therefore one focus, of the driver, which is to revolve with uniform speed. Assume any distance, as C F, between the foci, with which as radius, describe a circle about C. Divide the semi-circumference P F O into two parts, which are to each other as the time of the advance is to that of the return; in the case supposed, then, the angle A C F is to be one-third of its supplement, that is, 45° draw F P perpendicular to C F, cutting A C in P, which will be a point in the ellipse, whose major axis will therefore be equal to P F+P C.

For, making P A=P F, thus determining A the fixed centre of the follower, and constructing the two ellipses from the above data, in the positions shown in full lines, it will be apparent on inspection that while the driver moves as shown by the arrow through the angle F C I, or 90°, the follower will move through 180°, bringing the ellipses into the positions shown in the dotted lines, and the driver must make three fourths of its revolutions after that in order to carry the follower through the other 180°. Any point in the line of the major axis of the follower, then, describes a circle round D, which circle is divided by the vertical line K H into halves, in such a manner that the point takes three times as long to describe one half as it does to describe the other. Such point may therefore be connected as usual by a link to the tool-holder, which has a reciprocating motion in the line K H, the stroke in one direction being quicker than in the other in the required proportion. The nature of the motion depending



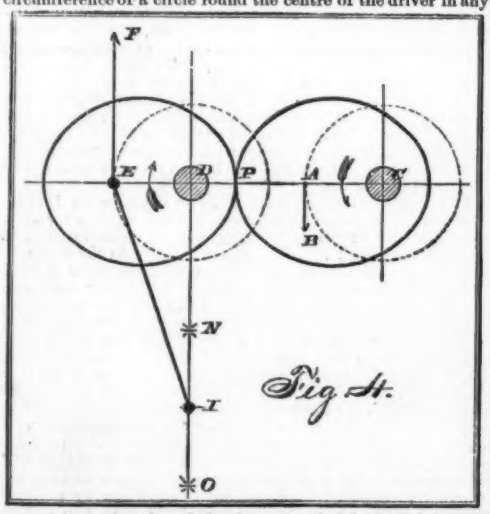
wholly on the forms, not at all upon the dimensions of the ellipses, the diagram may be made on any convenient scale for determining the relative lengths of the axes, if the distance C D, or in other words, the major axis, is given.

The second movement was employed for the purpose named by Sir Joseph Whitworth, though the details actually used were quite different from those indicated in the diagram, Fig. 3, which, however, clearly shows the action of the device, C being the fixed centre of the driving-crank C A, whose pin A moves freely in a slot in a second crank B D, which turns on the fixed centre D. As before, describing a circle round C with the radius C A, the semi-circumference is divided in the ratio of the times occupied by the advance and return. Thus we make F C A = ½ A C G, that is 45° ; then draw through A



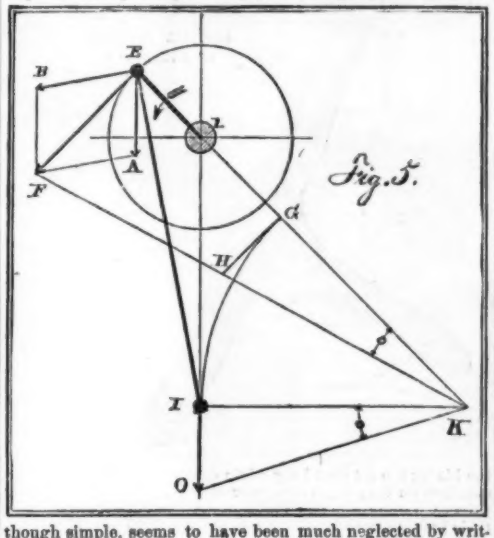
the line B D perpendicular to F G, the line of centres, which will determine D, and as before, mere inspection suffices to show that the motion of A through the angle A C H, or 90°, will drive B D through 180°. The link which moves the tool-holder in the line B E, perpendicular to F G, may therefore be jointed to any point in the line of the second crank.

The remaining combination is shown in Fig. 3 ; C is the fixed centre of the driving-crank C A, which is connected by the link A B with a lever B D, which vibrates through a definite arc on the fixed centre D, instead of rotating continuously as in the preceding case. In constructing the diagram, the angle A C F is made equal to 90°, as before (the whole circumference of a circle round the centre of the driver in any



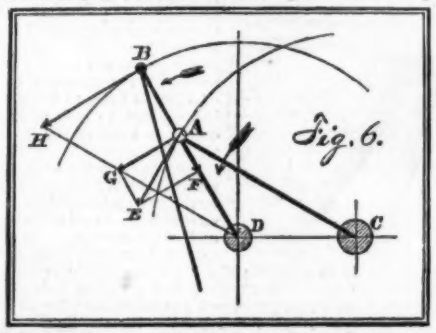
case representing the whole time occupied by both advance and return, is to be divided into parts having the given ratio of the times occupied by each respectively). Assuming the length A B of the link, set it off from A to B in the direction C A ; also from F to E, in the direction F C ; this determines E B, the chord of the arc described by the free end of the vibrating lever, of which the length is arbitrary ; but the fixed centre must lie as shown upon the perpendicular bisecting the cord B E. Taking D as this centre, it will be seen that the driving-crank in moving through A C F, or 90°, causes the lever to swing through the whole angle B D E, and the other three-fourths of the revolution are required to bring it back to its original position. The circular reciprocation may be changed into rectilinear by the intervention of another link ; taking the prolongation of B C as the line of motion, this link, G E, is jointed to a point G of B D, so chosen that the angular vibration of G E shall be equally divided by the line B E, as shown, so that the tool-holder traverses back and forth in the path K L M.

Now, it is not to be supposed that the speed of the tool-holder is uniform in either direction in any one of these arrangements ; and disregarding any other peculiarities which might make either preferable to the other, it is of interest to compare their actions in respect to the variations in this speed. One method of making such a comparison, and on many accounts the best, is by means of graphic representations of the motions. Admitting that calculated tables are useful, and in respect of minute accuracy superior, they do not and can not convey at a glance an idea of comparative velocities at different instants, which is precisely what is wanted, and precisely what can be done by diagrams, which are to tables and formulæ what drawings are to specifications and verbal descriptions. In the construction of such a diagram, we may proceed either analytically or graphically. That is to say, we may investigate a formula for a combination in hand, and from it calculate the velocities, or we may ascertain them by means of diagrams only. The first method is unquestionably the more precise, but the second is more expeditious, and with reasonably careful manipulation gives results sufficiently accurate for ordinary purposes. Now, the process of finding graphically the velocity of any moving point in a given arrangement,



though simple, seems to have been much neglected by writers upon such subjects. We therefore give here the steps by which the velocities were determined for the purpose of comparing the three movements above described, which depend primarily each upon a different one of the three modes of transmitting motion between rigid parts, namely, rolling contact, as in the pitch ellipsis, sliding contact, as in the crank-pin and slotted arm, and linkwork as in the last of the three ; while the constructions used involve all the leading principles necessary to making such determinations in any case.

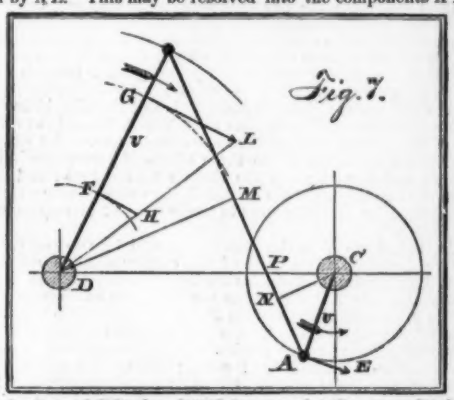
In Fig. 4, let C D be the fixed centres of the two ellipses whose point of contact is P, and E I the link by which the tool-holder is made to traverse in the path O N, the end E describing a circle about D with radius E D. About C describe a circle with radius A C=E D ; then the point A is supposed to travel with uniform velocity in this circle ; and as the direction of a curve at any point is that of its largest at that point, we may assume A B, of any length, perpendicular to C D, as representing the linear velocity of A. E F, perpendicular to C D, will then be the linear velocity of E in its circle, the length being found by the proportion $\frac{EF}{AB}=\frac{PC}{BD}$, for the angular velocities are inversely proportional to the radii of contact, and so are the linear velocities in this case, because E D=A C. But E is a point in the link, and since in the position shown it is moving in a direction parallel to the path of I, another point of the link, and this direction is not perpendicular to E I, the velocities of the two points must be equal :



E F, then, is the representation of the linear velocity of I in the direction I N.

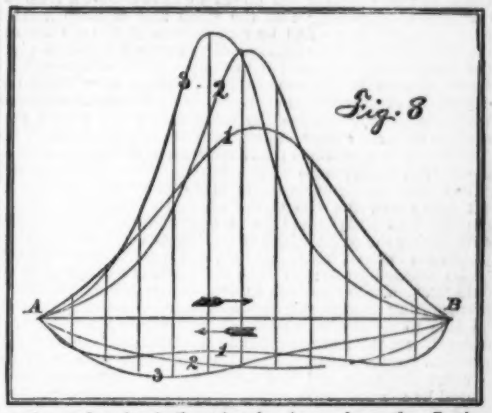
The crank-arm which moves the link is here shown as coinciding with the line of centres ; but in any position, it is clear that the motion of the *link* consists of a bodily reciprocation, combined with a rotation about the end I, which is jointed to the tool-holder. The velocity of this *rotation*, at any point of the link, may be represented by a line perpendicular to E I, that is, tangent to a circle of which I is the centre, the velocity of the *translation* by a line parallel to the traverse of the point I. Considering the circular motion of E, then, we have the directions of the two components into which it is to be resolved, which is done by making the given line representing its velocity and direction the diagonal of a parallelogram whose sides are respectively parallel to O N and perpendicular to E I : the former will be the velocity component of E in the direction O N, and also, since the link is rigid, the velocity of I at the given time. This is illustrated in Fig. 5, E F, perpendicular to E D, being the actual motion of E, and E B, E A, the two components above mentioned, of which the latter is the required velocity of I, in the direction D I. This this may also be found otherwise, thus : prolong E D (which is perpendicular to the path of E at the given instant) to cut at K the line I K, perpendicular to the path of I at the same instant ; then K is the instantaneous axis, about which E, I, and all points of the line joining them, are at that instant turning with, of course, the same angular velocity. Describe about K a circle with radius I K cutting E K in G, draw F K, and finally G H tangent to the circle at G, that is, parallel to E F : then G H will be the velocity of I in the direction I O ; as indeed will be evident if we draw the triangle I K O similar to E K F. When, therefore, the velocity of the circular motion of the crank or lever to which the link is jointed is known, either of these constructions may be used to find that of the tool-holder.

Fig. 6 shows the method of finding that circular velocity in the Whitworth movement. A C is the driving-crank, whose pin A moves in the circle round C, with a velocity represented by A E. This may be resolved into the components A F,



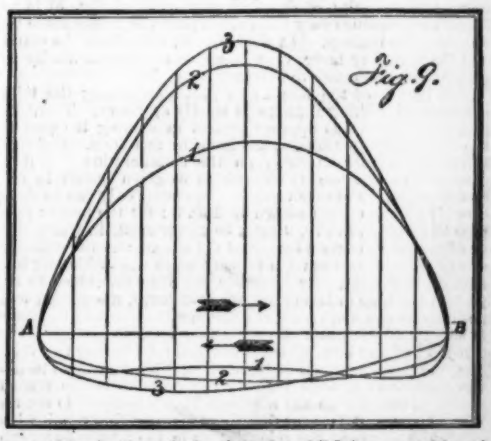
in the line of B D, the slotted lever, and A G perpendicular to that line. Evidently A F is the velocity of *sliding* of the crank-pin in the slot, and A G the velocity with which the point A of B D rotates about D. If, then, the link B I is connected at B, as shown, we find the velocity of that point by drawing D G, producing it to cut B H parallel to A G in H. Then B H is the required velocity, to be resolved as above explained.

The third movement is represented in Fig. 7, A C being the driving crank, whose velocity is A E; B D is the vibrating lever, A B the connecting-rod. The angular velocities of the crank and lever are to each other inversely as the segments P C, P D, into which the line of centres is divided by the con-



necting rod, or by similar triangles, inversely as the effective lever-arms C N, D M, perpendicular to A B.

Describe a circle round D, with radius D F = A C ; then F H is the velocity of rotation of F round D, its value being found by the proportion $\frac{FH}{AE}=\frac{NC}{DM}=\frac{PC}{PD}$. G is the point of attachment of the link moving the tool-holder, which is omitted in this figure ; having found the velocity of F, that of G is ascertained by drawing the triangle D G L similar to D F H, as shown ; from which that of the other end of the link is determined as in Fig. 5. We may simplify the construction a little ; since $GL=AE\times\frac{NC}{DM}\times\frac{DG}{DF}$, we may first find the value of $AE\times\frac{DG}{DT}$, and thus leave but one



construction to be made for the value of G L in any position of the parts, by the introduction of the variable factor $\frac{NC}{DM}$. All these determinations, it is hardly necessary to say, may be effected by the usual graphic means of finding the fourth proportional to three given lines ; whereby the whole problem is reduced to a series of operations to be performed with the instruments always in the draughtsman's hands.

Now, in order to construct the curve representing the varying velocity of the tool-holder, we proceed thus. If the curve is to represent the advance, divide the three-fourths of the circumference of the circle about the centre of the driver, in the movement diagram of the combination selected, into any convenient number of equal parts, and determine the position and velocity of the tool-holder, corresponding to each

point of division, assuming any velocity at which the machine may be supposed to run. Divide a right line representing the time occupied by the stroke, into the same number of equal parts, and perpendicular to it set up at the points of division ordinates equal in length to the velocities at the corresponding points in the division of the circle. A precisely similar construction is to be made for the return, except that as the motion is in the opposite direction, the ordinates are to be set off on the opposite side of the line. Since we have assumed that the advance takes three times as long as the return-stroke, and the lengths are the same, the average velocity in one direction is three times as great as that in the other; and since the product of the time by the velocity is the space passed over, and by this construction each time is represented by the same line, it follows that the area of one curve should be three times that of the other, the one representing the return motion being the greater because the velocity is greater.

For the purpose of comparison, the same line should be assumed as representing the time in each diagram, and the velocity of the driver should be the same in each case, under which conditions the areas of the three advanced curves should be equal, and also those of the three return curves; and the comparative actions of the several devices will be very clearly illustrated by the differences in the lengths of corresponding ordinates.

In Fig. 8 we give the curves, obtained by the processes above described, from each of the combinations, numbered 1, 2, 3, in the order in which they have been considered. The horizontal line A B represents the time, the advance-curves being below, the return-curves above. A comparison of these diagrams would seem to indicate the superiority of the first, since during the greater portion of the advance there is less deviation from uniformity of speed; and on the return, the maximum velocity is less, which is an advantage, as the return-motion may be made much more rapid than the advance without an objectionable amount of momentum being acquired.

Mathematical worshipers at the shrine of analysis are prone to sneer at the results of what they style "mere graphics," as crude and unworthy of the serene confidence to be reposed in well-managed symbols, as if the positive sign were the true cross; and many of them would no doubt feel a holy horror at the numerous "chances of error" involved in making such determinations, as these were made, entirely by instrumental construction. Now, we have a good test of the accuracy of the work, and of the reliability of the diagrams, by the comparison of areas which ought to be equal, and of others which ought to have a known ratio to each other. Assuming that the mean area is more nearly exact than either, we find by computation that in the case of the advance-curves the greatest discrepancy is less than $\frac{1}{100}$, the mean error less than $\frac{1}{300}$: in comparing the return curves the maximum is $\frac{1}{100}$, the mean $\frac{1}{300}$. There is, as might be expected, a greater deviation in comparing the advance-curves with the return, because the ordinates of the former are shorter, so that an error in determination would be greater in proportion to the whole; but here even the greatest discrepancy is $\frac{1}{50}$, the mean $\frac{1}{100}$.

But these constructions were made on a small scale, the cut being half the size of the original diagram; in actual practice that scale would be at least doubled, thus at once diminishing the probabilities of making an error, reducing its proportion to the ordinate one half, and quadrupling the area to be affected by it; so that it is safe to assert that a draughtsman who recollects that "a chance to make an error" means, being interpreted, an opportunity to be careful, will be able to make the areas correspond within $\frac{1}{200}$. This, as claimed, would be an approximation abundantly close for all practical purposes; and the graphic method, in addition to its obvious directness and expedition, may be intelligently employed by those who are unable to use the algebraic formulæ, and keeps a constant check upon the successive determinations, since the results of the preceding ones are always underthe eye.

Referring to Figs. 1 and 2, a study of the movements will show that the increments and decrements of the velocity-ratio are symmetrical with respect to the central position of the driver on both the advance and return. In each case, also, the follower will have made just half the semi-revolution required for the stroke, when the driver reaches that central position. From this it would at first sight appear that the velocity curves of these movements should be symmetrically divided by the central ordinates; and so they would be were the link (E I, Figs. 4 and 5) infinitely long, so as to be always parallel to itself: its varying obliquity is the cause of the distortion, which may be reduced by increasing the length of the link; this has in the construction of these diagrams been taken equal to three times the stroke. In the third movement the obliquity of this last link (G K of Fig. 3) is so slight as to produce very little effect; but the angles made by the main connecting-rod (A B of Fig. 3), with both the crank and the vibrating lever, vary in such a manner as wholly to preclude any approach to symmetry.

The length of the line A B, Fig. 8, representing the time occupied in making a stroke, is wholly arbitrary. There is, however, an obvious appropriateness in making it equal to the length of the stroke, as we have in fact done. And this fitness is the more evident, from the consideration that it is desirable to compare the velocities at given *points* in the stroke as well as at given *times*. The latter only can be done directly by the curves shown in Fig. 8: for the former purpose those given in Fig. 9 must be constructed, in which A B is, of course, the actual length of the stroke, and the ordinate at any point represents the velocity when the tool-holder has reached that point. By assuming the same line, then, to represent the time in laying out the first curve, the second will not only have a more natural relation to it, but may be readily set up at the same time, since, in order to determine the direction of the link, which is necessary in finding the velocity, the position of the tool-holder on that line must be determined, thus at once locating the ordinate of the second curve. Inasmuch as the abscissas in this last one do not represent times, it is clear that there is no definite relation between the areas and the velocities, as in the first. Nevertheless this curve is of interest and value in the study of the action of the mechanism, which, by the aid of the two sets of diagrams, is very clearly illustrated.

It may be worth while to add in conclusion that it is not pretended that the proportions above assumed are at all such as would be used in practice; unless in a very small machine it would not answer to make the return three times as rapid as the advance, and the third movement would very clearly be much improved by using a longer link and a longer lever. But, leaving these points to be determined by the designer according to the dictates of his own judgment, we have selected the proportions shown for the purpose of presenting the peculiarities of the motions in as striking a light as possible, the principles and methods involved being equally applicable under all circumstances.

[The Engineer.]

SCREW PROPELLERS.

By N. D. SPARTALI.

I GIVE a front end view sketch of my improved propeller, showing the blades set diagonally across the centre boss, and also the ends of the blades as set end to end at the extreme point of angle, also diagonally to each other, and, if the centre be forged, the lower ends or base of the blades will serve as rudiments or sockets, wherein the blades could be socketed by riveting, bolting, or welding, or otherwise be made fast, and lighter and stronger. By the concentration of these blades on to the centre boss, and by the nature of their angles to each other, and also by their perceptible inclination to the back of the axis, they not only follow each other in rapid succession in their forward action, but displace and cut, or slice the water at a long angle from that part to the front of the boss, and each blade acts beneficially on the centre water, and also what is called by captains backwater, or the water sucked or carried by the ship's stern on her progress forward, and their return upwards is effected at the extreme curved sides of the blades offering the least resisting surface to the water. In the Griffith's, as well as in most of the ordinary propellers,

the blades are set on a long plain centre, and in large ocean steamers on very large square or circular planes at a distance from each other, the one blade at half angle or diameter of their breadth to each other; and the four blades so placed are made to revolve round the large centre, leaving a large void in the centre and in its immediate periphery, owing further to the space intervening between it and the pitch of the blades, at an angle of 45 degrees or thereabouts, from the axis. Independent of this large mass of dead water, and of the back stern water detracting from the effect of the propeller, and to which I attach a greater amount of importance than what is generally believed by so-called practical men, owing to the above great pitch, or angle of the blade, a great deal of water is pitched from one side to the other of this large centre, and a great deal of it is lifted on the upward travel of the blades, causing accumulated resistance and useless waste of engine power, and a great deal of friction of the metal to the water and spattering of the water between the blades, well known to engineers as centrifugal action.

The results I obtained in my models, driven by steam at a great speed, are an increase of speed of from 10 to 15 per cent on the other propellers, and, what is most important, a considerable saving in the quantity of steam supplied to the engines, as much as that required to drive the Griffith's and other propellers, which I have been able to ascertain by the relative fall of pressure indicated by my most accurate little pressure gauge fitted on to the copper boiler supplying the engines, the loss in pressure with my propeller being of 3 lbs. to 4 lbs. to 5 lbs. to 6 lbs. per square inch with the others on a run of 100 ft. each time.

My experiments with little steam models have been various and extensive, and conducted with a great deal of accuracy and observation, and no little care and trouble. My object was principally to ascertain the highest possible speed that such could be driven by carefully and skillfully constructed engines and the best constructed propellers, as also as compared to the best engines and paddles for paddle steamers. My models are all of one length, say 5 ft. 6 in., 8 in. beam, and one model same length by 10 in. beam.

My first experiment was with a model with a rather bluff entrance to the water, not very fine lines aft, but what only a few years ago would have been considered a fair specimen of an ocean going steamship; her engines were two vertical oscillating cylinders of the ordinary construction. Drawing 6 in. of water and driven by a 5 in. Griffith's propeller, I have run her the measured distance in the canal in 28 seconds, and with my propeller, same distance, same everything, in 25 seconds.

My second experiment consisted of a model specially constructed on my own lines, same length, 5 ft. 6 in. by 8 in., beam very flat, and very gently rounded bottom, centre with fine entrance, and long lines under her water line, with a clear run to the poop aft, but not extra fine lines gradually tapering—a hull of comparatively large cubic capacity on a light draft—such a vessel as would be suitable for the New-Orleans trade. Drawing 4½ in. aft, with about 15 lbs. of ballast (lead), besides her boiler weighing 9 lbs. to 10 lbs., and its content of water another 4 lbs. to 5 lbs., say total dead weight about 30 lbs., besides her keel being partially weighted with lead for stiffness on the water when used as a paddle boat. I have also had specially constructed a pair of compact inverted cylinder-engines most faithfully and most correctly put together, very light material, but very true and strong in all their working parts, slide valve, spindles, cranks, and bearings—sufficiently strong, in fact, to stand the shock and friction of a terrific speed of piston. The revolutions I have obtained from these engines (pigmy engines) is no less than from 1500 to 2000 per minute; with ordinary Griffith's propeller she ran the measured distance in the canal of 100 ft. with full boiler power at a pressure of 40 lbs. to 45 lbs. of steam per square inch in 17¼ to 18½ seconds, and with my propeller in 16 to 17 seconds, but the falling off in the pressure of the steam was 6 lbs. to 8 lbs., with the ordinary propellers, and only of 3 lbs. to 4 lbs. with my propeller, the heating surface and the quantity of heat supplied (spirit wick burners) being the same in all trials.

My third experiment as follows: The said model being well suited to carry paddle-wheels, I had a pair of the most perfect and modern set made, fitted with feathering gear such as are, in fact, fitted with the Isle of Man fast passenger boats sailing daily from Liverpool, their diameter being 9 in., with number of floats in proportion, three catching the water at every revolution, perhaps 3½ inches each side, I also had constructed further a pair of the best type of side-lever two-cylinder long stroke engines, working at a great speed, and worked admirably with the same boiler as for the screw engines, with the same amount of heat, etc. The speed of this little paddle yacht model was so good that she attracted general attention when she was run in the lake in Newsham Park, yet in the measured distance of 100 ft. in the canal the time she made was no less than 25 seconds, as against 16 to 18 with the screw; a clear gain in favor of the screw propeller of no less than 40 per cent.

Fourth experiment: This was effected with a specially arranged model for testing the accuracy of Mr. Griffith's theory of the advantage of bow and stern propeller and efficiency. The gain in speed he makes on the collective propellers over the single stern propeller is 40 per cent by doubling his power. This model is much finer fore and aft than the previous one, and the bottom centre gently barreled, shape a good type of an ocean-going steamer. Two finely cut and smoothly finished longitudinal arches with hollow roofs were cut under the ship's bottom, protruding at a height from the floor of the hull internally, and right across the keel, under the bottom aforesaid, the one arch about one sixth from the forerake, and the other about equal distance from the stern post; into each of these arched vaults a propeller of 4½ in. diameter was fitted and connected to one main shaft and to the engine, and worked by the same boiler as used in the former model and in a line with a shaft as nearly as possible all but touching the hull's floor, to obtain the requisite rectilinear level with the axis of the respective propellers outside. This model so fitted has run the distance of the measured line of 100 ft. in 18 to 19 seconds. The same model, fitted with two separate shafts and two distinct pairs of engines to each screw, gave precisely the same result without any increase of speed whatsoever, and with half speed of the stern engine,

and full speed of the forward engine, the loss in speed was 5 seconds in the distance of 100 ft., namely, 100 ft. in 24 to 25 seconds, pressure of steam and all conditions always the same. Similar result with full speed to stern engine, half speed to forward engine. The forward engine and propeller worked at full speed alone gave 2 seconds less speed in 8 to 10 per cent loss on the stern propeller worked alone with full power.

My sixth experiment consisted of a peculiarly-constructed model, a fine gently tapered V-shaped hull, all lines from stem to stern a little fuller in the centre broadside under the water line, but gently barreled upwards, and in proportion for the whole length from the point of the water or load line upwards above the water line, with a great breadth of beam—10 in.—the wide deck covering the ship from end to end like a floating bridge, the length being always the same, namely, 5 ft. 6 in. This model of half as much capacity as the flat-bottomed one mentioned in my second experiment, and drawing 5½ in. to 6 in. of water, or 1 in. to 1½ in. more than that driven with same boiler and engine, has given with a 4½ in. propeller nearly the same speed as the above-mentioned, but as regards stability and steadiness in the water she is a perfect specimen; she appears as firm in the water at full speed as a locomotive on the rails, and is admirably fit as a type for a Channel passenger steamer, and equally, if not better, for a heavy turret man-of-war carrying heavy guns.

The inevitable conclusion of these experiments is: (1) That skillfully and accurately constructed engines for high pressure, made light but strong, can be made to work at an incredibly high speed, although relative to the size and work to be done. In these small engines the speed of 1500 to 2000 revolutions is wonderful, and beats even the small electric engines by far. (2) That a fine model, with perfect engines and perfect propellers, or as perfect as can be made by man, will run 40 per cent faster than a full model with ordinary engines and propeller. (3) That such a fine model, fitted with perfect engines and propeller, will run 40 per cent faster than the best modeled, the best engined paddle-boat steamer fitted with the best made and most improved set of paddle-wheels, with feathering gear the most approved, and furthermore, with one-third of the engine power. (4) That a single propeller, and in preference a stern propeller, will drive such a model as fast as two propellers—bow and stern—whether these latter be driven by the same or by separate engines; consequently, that vessels fitted with two sets of propellers, or two sets of paddle-wheels and, I may also observe, twin vessels are the greatest engineering errors of our time. The models driven by these propellers keep a wonderfully straight course on the water as if steered to her course, and a clear stream without commotion in the immediate back of the ship's stern is the result.

EVAPORATION AND PERCOLATION.

BEFORE the Institution of Civil Engineers, Mr. George Robert Stephenson, President, in the chair, a paper on "Evaporation and Percolation" was read by Mr. Charles Greaves, M. Inst. C.E.

This paper treated only of evaporation due to natural in-

fluences, from observations at Lee Bridge. It contained a proposal to gauge, by an apparatus as simple as an ordinary rain-gauge, the loss of water from the re-evaporation of rain; the usual method of learning the hygrometric state of the air being by the dry and wet bulb thermometers. The gauges included a percolation-gauge, which was larger but did not differ greatly from the Dalton gauge, started by the late Mr. Dickenson at Abbots Langley, to which the author had added one filled with fine sand to ascertain maximum percolation. Lastly, evaporation from a surface of water was determined by floating the gauge in a vessel, or in some river, open tank, or reservoir, and it was assumed that the water in the inner vessel acquired the general conditions of that in the outer vessel. The rain-gauge and percolation-gauges were not new, but the form employed for determining the amout of evaporation from a surface of water had not been proposed elsewhere; moreover, the four series of observations had never been brought forward in juxtaposition and with apparatus of uniform construction.

Tables were submitted of the rainfall from observations uninterruptedly maintained since 1855; of the percolation, which by subtraction showed the evaporation from the ground since 1855; of the percolation through sand, which furnished also the evaporation from sand, since 1860; and of the evaporation from a surface of water. The author gave the average rainfall as 25 in., the average percolation through sand as 20 in., and the evaporation from a surface of sand as 5 in.; percolation through earth as 7 in.; evaporation from a surface of earth as 18 in.; evaporation from a surface of open water 20½ in.; and the gain of water in an open tank 4½ in. only. These tables showed that all the water that could be relied on as retained for use was a depth of 7 in., if the rain fell on a permeable soil, and of 4½ in. if it fell on an open tank or reservoir. To secure more than this, covered reservoirs or close vessels to prevent evaporation would be necessary. The principal deduction from the facts observed had been the smallness of the remainder of the rain-water left after the influence of evaporation had been felt, and this was noticeable whether the water had been at once stored in reservoirs or had been allowed to sink into the porous earth, and was stored there. In either case the proportion unevaporated was small, the average annual result from fourteen years' observations showing 5.108 in. of water as added to an open water surface, and 7.582 in. as absorbed by the ground, the results of nineteen years and twenty-two years indicating still less, as had been mentioned. Certain geographical limits must be given to these data, which, excluding Wales, Devon, and Cornwall, would probably be applicable all over the south of England, and as far north as the Trent and Severn. The northern counties, Scotland and Ireland, would have different ratios of evaporation, and doubtless the springs were better fed.

The phenomena of peculiarly dry years—years in which the rivers and springs had been deficient (namely, 1861, 1864, 1868) were discussed. Springs and rivers had been redundant in 1852–53, in 1857–58, in 1860, in 1866, and in 1872. It was manifest that with a view to provide for the permanent and continuous needs of large communities, the probable fluctuation of delivery of water in a river might be gathered by watching closely the sequence indicated by the percolation-gauge. Heavy rains and storms in summer might produce a river-flood, yet fail to replenish the springs; and a long frost, even with considerable snow, might leave rivers and springs very short of water for the following autumn; and a dry winter imperilled the permanence of river discharge more than a hot summer. The latter, however, might succeed a dry winter, under which circumstances the deficiency of water in the rivers must become alarming, in view of the present tendency to the aggregation of populations. One result of the comparisons deduced from the tables attached to the paper was, that the storage of water might be more safely and largely secured in a porous subsoil, covered with a turfed surface, than in ponds, reservoirs, or other accumulations of open water. The author added that frequent thaws of small falls of snow produced the greatest amount of percolation; that hollow draining did not diminish the perennial flow of rivers; that capillarity had only a negative influence; and that the influence of a wet period on percolation rarely extended over more than one season, and was soon obliterated by a dry winter succeeding.

The flow of springs and of rivers followed the increase and decrease of percolation more closely than the rainfall, except in the temporary effects which immediately succeeded on copious rains. Negative evaporation, or an incremeut of water without rain, occasionally, though seldom, occurred in the floating-gauge; but it was of frequent occurrence in the sand-gauge, from the low temperature acquired by the sand by radiation, when the gauge became a dew-tank.

THE 81-TON GUN.

SINCE we last recorded the results of the second series of experimental firing of the 81-ton gun, the bore of this weapon has been enlarged from 14½ in. to 15 in., and in the course of last week a third series of rounds were fired from it with the view of ascertaining its performances under the altered condition. The results obtained, and which are recorded below, were highly satisfactory, and although the differences, as compared with the first series, are small, they indicate increased velocities and reduced pressures in the gun. It will be noticed, too, that the pressures were very uniform, with the exception of that in the third round, which rose above the 25 tons per square inch assumed as the safe working limit, and compares with those exceptional pressures recorded in the fifth and sixth rounds of the first series where, with charges of 230 lbs. and 240 lbs. of powder, the pressures were 29.6 and 27.3 tons per square inch respectively, and with the eleventh round of the second series, in which, with a powder charge of 220 lbs. of 1.5 in. cubes, the pressure amounted to 28 tons per square inch.

Number of Round.	Size of Powder.	Weight of Powder-Charge.	Weight of Projectile.	Muzzle Velocity.	Total Energy in Foot-Tons.	Foot-Tons of Energy per Inch of Shot's Circumference.	Foot-Tons of Energy per Pound of Powder.	Mean Pressure in Gun.
	in.	lb.	lb.	ft.	tons.	tons.	tons.	tons per sq. in.
1	1.7	220	1360	1513	19,994	424.32	90.88	21.0
2	1.7	220	1360	1546	20,789	441.19	90.39	22.0
3	1.7	220	1460	1471	21,907	464.92	99.56	26.3
4	2.0	250	1360	1536	20,607	437.32	80.25	23.2
5	2.0	220	1460	1364	18,829	399.59	85.58	24.4
6	1.7	220	1460	1494	20,529	435.60	93.31	23.8

Arrangements will shortly be made for the transfer of the gun to the long ranges, where it will be tried against armor-plates. The ultimate capacity expected when the maximum bore of 16 in. is reached, is a penetration of 27 in. of solid armor at a range of 1000 yards, and with a shot weighing 1800 lbs. If the statements recently published in the *Times* be correct, the performance of the great Krupp gun recently tried has given higher results than those recorded above. The weight of this gun is 57.5 tons, and its calibre is 13.78 in. The projectile weighs 1210 lbs., and the powder-charge is 297 lbs. In recent experiments it is stated that an inflexible target with 24 in. plate was pierced at a distance of 1968 yards. The muzzle velocity is given as 1640 ft., which would give a total energy in foot-tons of about 22,600, and per inch of circumference of bore, 523 tons. The foot-tons per pound of powder-charge, however, falls to 76.1, showing that the weapon is strained far more severely than our 81-ton gun, and it is to be regretted that the pressures per square inch are not published; they must be of necessity very great.—*Engineering.*

ACTION OF GUNPOWDER IN THE BORES OF GUNS.

A PAPER on this subject was lately read by Captain C. Jones, R.A., to the members of the Royal Artillery Institution, Woolwich, at a meeting held in the theatre of that institution. As a member of the Experimental Branch of the Director of Artillery's Department, Captain Jones is constantly engaged with the instruments employed by the Committee on Explosives for investigating the action of gunpowder in the bores of guns, and the announcement that he would describe those appliances and the results obtained by their use, drew together a large assembly of the scientific corps, amongst whom the subject is regarded as one of the foremost of modern artillery studies. Colonel Younghusband, Superintendent of the Royal Gun Factories, and president of the Committee on Explosives, occupied the chair.

Captain Jones commenced by stating that immense progress has been made during the last few years in the investigation of "fired" gunpowder, resulting in considerable improvement in the service powder, and a great increase in the power and safety of heavy guns. Up to 1869, when the Committee on Explosives was appointed, England used the old-fashioned powder, quite unsuitable for large guns, and in 1870 the pebble powder was introduced, which, although it consisted of cubes less than half an inch in diameter, was a step in the right direction. Experiments with the 38-ton and 81-ton gun had, however, shown that the size of the grain must be further increased to produce a powder suitable for the enormous charges which these guns consume. The lecturer then proceeded to describe the Boulengé chronograph, by which the velocity of the projectile is measured just after leaving the gun; the crusher gauge, which records the pressure chronoscope, which is employed to measure the velocity of the shot at successive stages inside the gun. The Boulengé instrument consists in the main of two electro-magnets, suspending two metal rods. The shot is fired through two screens, at known dtstances apart, and by severing the electric currents, demagnetises the magnets, and liberates the metal rods. The fall of these bodies, under the action of gravity, is the measure of the time taken by the shot to pass between the screens. Two of these instruments are employed at each observation, and they do not vary the thousandth part of a second. In the crusher gauge, a small cylinder of copper is crushed between a piston and anvil by the pressure of the powder-gas, and the results are found very reliable. Its extreme simplicity, combined with great accuracy, have rendered it invaluable, and nearly every description of gun, from the 9-pounder to the 81-ton, have been tested with it. The 38-ton gun is bored for crusher gauges in seventeenth places—one at the rear of the chamber, and the others a foot apart up to within 6½ inches of the muzzle. Numerous experiments were cited to show the character of the information thus gained, the general result being to show that with 130 lbs. of a slow-burning powder and 800 lb. shot, the pressure diminishes gradually towards the muzzle, starting at about 26 tons on the square inch and coming down to a pressure of one ton or less at the mouth of the gun. The Noble chronoscope, which records to the millionth part of a second the time at which the shot passes several stations inside the gun, affords equally interesting and important details. Beginning at a speed of 22 feet per second, the shot in its flight of 3 inches acquires a velocity of 388 feet, which, as more gas is generated increases to 562 feet at 6 inches, 820 at 1 foot, and so on progressing at a diminished ratio until it leaves the muzzle with a velocity of 1527 feet per second. This was an experiment with the 10-inch gun, using 76 lb. of pebble powder and a 300 lb. shot. Trials of other guns and different kinds of powder in varying charges had produced results of a different character, the comparison of which had been of the greatest possible value to artillerists. The chronoscope invented by Captain Noble, late Royal Artillery, was minutely and clearly explained by the lecturer. It consists of a series of metal discs, revolving at a high speed by means of a heavy weight, and a train of gearing multiplying 200 times. The principle of action consists in registering by means of electric currents upon the edges of these discs the precise instant at which the shot passes the points in the bore with which they correspond, and so accurately do they accomplish this that errors never exceed a few millionths of a second, to illustrate which the lecturer remarked that the millionth part of a second bears about the same proportion to a whole second as a second does to a fortnight.

REMARKABLE CABLE TELEGRAPHING.

A SUIT has been brought by the city of Philadelphia to enjoin the Western Union Telegraph Company from placing poles in Tenth street, and to compel the company to run its wires underground. It was recently argued in the Court of Common Pleas No. 4, and affidavits from Mr. David Brooks and others showing the feasibility of operating subterranean lines were submitted. A question of fact arose as to whether underground wires in Europe had proved satisfactory. It was alleged on behalf of the defendant that such enterprises had almost invariably been abandoned, while on behalf of the city it was insisted that this was the method now in universal use in Great Britain and Continental Europe. The City Solicitor telegraphed to the post-office authorities in London early in the day, making inquiries in regard to the matter, and before noon a reply was received and read to the Court.

The following are the despatches referred to:

"PHILADELPHIA, March 6th, 1876. Charles T. Fleetwood, Chief Post Ofs. Telegraphs, Gen. Post Ofs. London, E.C.: Will you please inform me, by cable, whether the underground wires in London, referred to in your paper in the *Electrical Review* of January 15th, are in successful and perfect operation, and perform the same and as good service as if erected upon poles, and for how many years have they been performing such service satisfactorily?

"Are telegraph-poles in use in the principal streets of London or of any of the cities of Europe?

"In a case at this moment being argued between this city and the Western Union Telegraph Company, the latter contends that underground telegraphy has proved a failure in Europe. Is this so? CHAS. H. T. COLLIS, City Solicitor."

LONDON, March 6th, 1876. Charles H. T. Collis, City Solicitor, Philadelphia: The underground wires in London, referred to in Mr. Fleetwood's recent paper, are in successful operation. It would not be possible to carry the same number of wires through London by overground work, nor would it be desirable, considering the atmosphere; but there are some overground wires which are carried over the housetops. There are no poles in the streets. All the important wires have been carried underground through London for the past twenty-five years.

"Pole and underground lines are in use in Continental cities.

"W. H. WINTER,
"Assistant Engineer in Chief, General Post Office, London, England."

The despatches were transmitted over the Atlantic and Pacific, and Direct Cable lines, and the time made was remarkable and the shortest ever made between Philadelphia and New-York. The despatch to London, which contained 126 words, was transmitted from Philadelphia to London, over land and cable lines, in twenty-three minutes; and the reply, which contained 108 words, was transmitted from London to Philadelphia in twenty-two minutes. The actual time in transmission of the despatch from London over the cable line was six minutes, the rest of the time being occupied in the transmission and repetitions over the land lines connecting with the cable.

[Nature.]

ON THE SPECTRUM OF NITROGEN AND THAT OF ALKALINE METALS IN GEISSLER TUBES.

IN 1872 Mr. Schuster published the important statement that "nitrogen, heated in a Geissler tube with metallic sodium, ceased to give the characteristic channelled spectrum." He described the bright lines he got in this case, and attributed them to pure nitrogen, considering the band spectrum to be that of an oxide of nitrogen, a compound destroyed by the alkaline metal. These conclusions were afterwards disputed, for, in repetition of the experiments, the channelled spectra were seen to disappear after action of the sodium, but they were replaced by various spectra, none of which belonged to nitrogen; so that, after its purification, this gas could not be detected by prismatic analysis. The chemical compound really formed by the action of oxygen on nitrogen is (as M. Salet pointed out) peroxide of nitrogen, a very stable substance, whose spectrum does not coincide with that, the appearance of which is to be explained.

In a recent note to the French Academy, M. Salet affirms (1) that the channelled spectrum may be produced with nitrogen heated in contact with sodium; (2) that the disappearance of the nitrogen spectrum is due to that of the nitrogen itself, which is entirely absorbed by the sodium under the influence of the electric discharge; (3) that the spectrum described by Mr. Schuster may probably be attributed to vapors of the alkaline metal.

He describes some of his more decisive experiments. A closed tube of hard glass was procured 12 cm. long and 2 cm. in diameter; at one end were introduced two aluminium electrodes, about 1 cm. apart; to the other end was soldered a tubulure with an enlarged part, into which was put a small piece of sodium, then the tubulure soldered to the mercury pump. A vacuum having been made, the sodium was heated; it swelled and boiled, parting with hydrogen; the swelling at length ceased, and at a higher temperature the sodium was slowly volatilized. Then the apparatus was separated from the pump with the blowpipe, and the bright liquid and globule of sodium was brought into the tube. After cooling, the enlarged part was separated, and the tube directly fused on to the pump. Then exhaustion was recommenced, and the sodium volatilized, care being taken that the condensation of the metallic vapor occurred only in the half of the tube not holding the electrodes; and nitrogen, pure and dry, was then admitted. A vacuum was produced anew three times with the nitrogen, the alkaline metal being volatilized each time. Lastly, the apparatus was closed, having a pressure of about 5 mm. It was now possible to fuse the globules, unite them, and volatilize them afresh a dozen times in contact with the same mass of gas, without the appearance of the spark between the electrodes being in the least degree modified. The Holtz machine was used, or an induction-coil with a Leyden jar; the interpolar space was roseate violet, and gave the channelled spectrum with the greatest distinctness. When the disruptive spark of the Holtz machine is employed, the jet of roseate violet light giving the channelled spectrum is instantaneous, as can be shown by a simple method (which M. Salet described). By volatilization the sodium may easily be brought to the neighborhood of the electrode. It there appears in the form of brilliant globules of a very pure silver white; but if the tube be set in action, the portions subjected to the action of the luminous discharge are at once tarnished. The metallic surface quite disappears, and is replaced by a brownish black. At the same time one sees in the appearance of the electric jet changes produced which are caused by a greater rarefaction. If the surface of the sodium be renewed the action continues, and the spectrum of nitrogen presently quite disappears; the light is yellowish, and due, for the most part, to sodium; there are, in general, slight impurities (from the electrodes and glass), which give some strange lines.

M. Salet made a direct experiment to show this absorption of nitrogen by sodium under the influence of electricity. He made a tube like the one that has been described, but bearing a truncated barometer; and introduced nitrogen at a pressure of 27 mm. The absorption of the gas was sufficient for one to be able to follow with the eye the ascent of the mercurial column. After a few minutes, having twice renewed the surface of the sodium, no difference could be perceived between the mercury surfaces in the two branches of the manometer.

The author also sought to characterize this absorption chemically. He broke a tube and treated separately with water a portion of the sodium remaining bright and a portion of the sodium altered by electricity. Into the solution he poured Nessler's test. One of the two liquids was strongly colored yellow; it was that containing the altered sodium, the other was not altered in aspect. There was formed, then, under the influence of electricity, nitrite of sodium decomposable by water with production of ammonia. This body is formed only at a temperature higher than red, like nitride of magnesium; or even is not produced directly at any degree of heat, like ammonia. M. Salet proposes to prepare and analyze it.

IRON ASSAYING.

By BRUNO KERL Professor at the Royal School of Mines, Berlin.

No. 1.

BY the assay for iron we understand the determination of the various substances used in the smelting of iron—ores, fluxes, and fuel, and of the products of the smelting-furnace—pig-iron, wrought-iron, steel, slag, etc.

Before the assay proper can be proceeded with there are certain preliminary operations to be gone through. Among these are:

FIG. 1.—Water-bath. Copper box with hollow sides, water-lined.

(1) *The Selection of Samples.*—The selection of samples of ores, slags, etc., has to be so effected as to secure obtaining those which will exhibit the average composition.

(*a*) Averaging by division, the specimens being of equal quality. This operation comprises the following details: Taking samples up to several cwt. from different parts of the top of a heap, as well as from its interior, without, however, selection; reduction in stamping or rolling mills, or under the hammer on iron plates to pieces of about the size of a bean; shoveling the mass into a conical heap; division by the shovel into halves or quarters; further reduction of these in the steel mortar to pieces not exceeding a pea in size; a second heaping and halving, and further reduction until an average test-quantity of from half a kilogramme to 1 kilogramme of the powdered substance has been obtained.

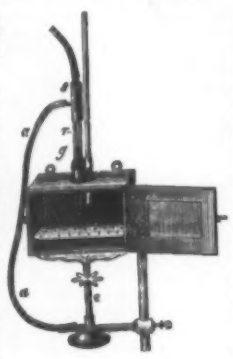


FIG. 2.—Air-bath.

(*b*) Averaging by commixture, the specimens being unequal in quality. The details of the operation are as follows: Spreading the heap out in a layer 30 to 40 centimetres thick; channeling the same by making channels in it 20 to 30 centimetres wide in the direction of its length and breadth; reduction by milling, stamping, or hammering of the portions removed in channeling, until they come down to the size of a hazel-nut; the formation and rechanneling of a second layer from the reduced mass; and repetition of the operation until a test-quantity of pulverized substance is obtained, of the weight mentioned above.

(2) *Preparation of Sample.*—The powdered ore has to be dried in an iron or copper dish, which should measure about 28 centimetres in length by 22 in breadth and 6 in depth, the

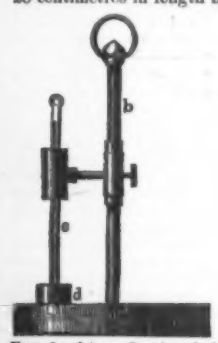


FIG. 4.—Disc.

FIGS. 3 and 4.—*a*, Cast-iron drying disc, 25 cm. across, 4 cm. thick, heated from below; *b*, handle, 36 cm. high; *c*, brass pans with numbered handles; *d*, pan filled with copper filings to receive thermometer *e*.

heat being that of a gentle charcoal fire, and not much exceeding 100 deg. C., the dish is placed over a stove or sand-bath; stirring goes on till dust rises; and is followed by trituration in a steel mortar, sifting through a sieve with fifteen or twenty holes to the linear centimetre, mixing the siftings, and repeated passing through a coarser sieve; the sample, when obtained, is placed for preservation in wooden or tin boxes or glass bottles. For many assays the fineness of the powder is a sufficient test, whilst in others, particularly where the substances are not easily soluble, further trituration in an agate mortar is necessary. *White pig* is pulverized in the steel mortar and passed through a sieve with holes of 0.4 or 0.5 millimetre in diameter. *Grey pig* is mostly taken in the shape of bore chips, since, in filing, graphite dust may be lost. *Steel* and *wrought iron* should be filed off from the end of a rod, at right angles to the length; filings taken from the outer surface only may possibly contain less carbon than those from the middle.

FIG. 5.—Crucible stand with porcelain base. *a*, fixed upright; *b*, movable arm supporting crucible; *c*, ditto supporting Bunsen burner, *d*, and dish *e*.

(3) *Weighing.*—In weighing the powdered ores, slags, etc., the powder has to be thrown out in a heap, on a piece of glazed paper, and spread out in spiral lines by means of an assay spoon,* these are gathered together into a heap, after redistribution in radial lines; a portion of it is taken out from the lower part of the heap upwards, and weighed on the pan of a trial balance which will weigh up to 30 or 50 grammes, and show a difference of 1 milligramme when the scales are equally loaded up to 5 grammes. For very accurate work chemical balances, which turn the scale at one-tenth milligramme, are needed, the substance (pig-iron, bar-iron, steel, etc.,) being placed in a glass tube, platinum crucible or watch-glass.

(4) *Drying.*—For estimating the amount of hygroscopic water contained in the substances, they must be dried. For this we use a water-bath made in copper (Fig. 1), contrived for drying at 100 deg. C., capable of receiving crucibles, pans,* watch-glasses, filters, etc., containing the substance to be dried. A porcelain pan with funnel can be disposed in it by being placed in a collar over a cast-iron pan filled with cold water, so that the porcelain remains always above the water level. A water-bath of this kind, with constant level, is arranged by having a short horizontal tube connected at the bottom with an upright pipe, into which water trickles constantly from above, the excess being carried off by a central pipe placed so that its opening is on a level with the surface of the water in the bath. If higher temperatures—120 to 130 deg. C.—are required, a simple air-bath or Bunsen's air-bath is made use of. The former is a cylinder in sheet copper, 100 millimetres in height and 80 in breadth, standing on a tripod support and provided with a cover that can be removed at will. The lower part of the cylinder and the cover are perforated with openings for draught, and a perforated horizontal plate is placed at 26 millimetres above the bottom to receive the saucers, etc., which contain the substances for drying. A thermometer passes through the cover. In Fig. 2 is shown a Bunsen's air-bath with regulation for temperature. In the drawing, *q* is a tube passing into the air-bath. It is filled with quicksilver up to the mark at *q*, and has at foot an air-bulb opening downwards and closed by the quicksilver; *s* is a broader tube dipping from above into the quicksilver; the small tube, *r*, is made to fit close at top into *s*. At its superior extremity *r* is connected with the gas-supply pipe; below it has a long narrow opening, at top a pinhole in its side; it can be moved upwards and downwards by a screw-nut. When turned on the gas flows into *r*, then through the narrow opening at *q* into the broad tubes, and from this through *a* into the burner *e*. When the temperature of the bath rises, the air in the lower part of the tube *q* expands, the quicksilver rises, and partly closes the slit in *r*, so that less gas is admitted; when the temperature sinks these operations take place in a reverse order. A higher or lower constant temperature is secured by giving to the admission tube *r*, relatively to the level of the quicksilver, a higher or lower position. Porcelain instead of metal air-baths are made use of when fluids are to be heated, such as fluor compounds, or others which give off corrosive vapors. Drying at a given temperature can also be effected by means of the drying disc (Figs. 3 and 4). If this is made drum-shaped in sheet iron, about 6 centimetres high, the upper and lower plates provided with corresponding holes, funnels, and filters can be placed in it for warming. Hygroscopic substances, before weighing, are cooled in a desiccator. This is a glass cylinder closed air-tight by a ground-glass plate; within the cylinder are placed a tripod support in iron wire, and a quantity of chloride of calcium, or pumice-stone soaked in concentrated sulphuric acid. The cylinder is from 6 to 8 centimetres across, and 10 to 12 centimetres high. The hygroscopic substances are best cooled between a pair of watch-glasses held together by a brass clip.

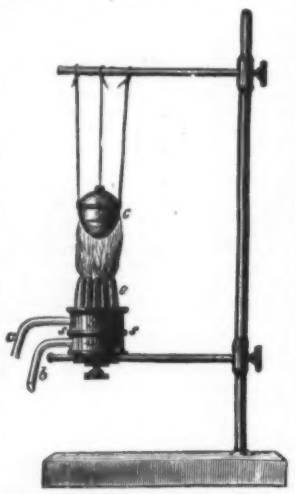


FIG. 6.—Sonnenschein's lamp. *s g*, diaphragm separating air-space *w*, and gas-chamber, *g*; *c*, five Argand burners, whose inside tubes reach to *w*, the outer tubes to *g* only; *a*, gas-pipe; *b*, air-blast pipe; *c*, crucible.

(5) *Igniting.*—For ignition, the substances are heated in a platinum or porcelain crucible, according to the temperature required, over a spirit lamp, a Bunsen's burner (simple or compound, fitted with proper upright), or, when higher temperatures are desired, a Sonnenschein air-blast lamp (Fig. 6); heating is also carried out in a covered earthen roasting pot, some 51 millimetres broad and 8 millimetres deep, in a small muffle-furnace with charcoal fire, gas-furnace,† or petroleum vapor-furnace (Deville, Paris); or in a large muffle-furnace heated with common coal; the heated substances are gradually cooled in the desiccator before weighing. When a precipitate has been dried on a filter, the former should be separated as completely as possible from the latter, and thrown into a porcelain or platinum crucible; then follows the division of the filter into several pieces; ignition of the same one after the other upon the cover of the crucible; addition of the ashes to the contents of the filter and heating of the latter; or, folding the emptied filter into a compact cylinder, binding it spirally round with a thin platinum wire; holding the cylinder, after its deflagration, in a non-illuminating Bunsen flame, by one end of the wire over the crucible; and shaking into the crucible the ashes of the filter. The known quantity of filter ash has to be subtracted after weighing the whole.

* This should be of brass, 180 millimetres long, with a width at the front end of 20 millimetres, widening out to a spatula at the other.

* See, for water-bath adapted to several pans, Fresenius, Ztschr., 1869, pp. 46, 601; safety appliances, *ib.*, 1870, p. 356; 1871, p. 200; self-registering bath, *ib.*, 1871, p. 88.

† "Berg- u. hüttenm. Z.," 1870, p. 360; 1872, p. 386.

THE TEMESCAL TIN MINES.

THERE is a prospect of an early resumption of operations in the Temescal tin mines in San Bernardino County. These mines are situated about 24 miles southeast from the new settlement known as Pomona. During the past ten years but little labor has been performed in these mines on account of a conflict in regard to the title. The property is reputed to be immensely valuable, and it is unfortunate that an industry of so much importance should languish on account of a wrangle over the right of possession. But it appears that the conflicting interests will soon be smoothly straightened out, and that a company of foreign capitalists will vigorously take hold of the work. The prospective operators are wealthy gentlemen from Amsterdam, who are engaged in importing tin from the United States on an extensive scale. The value of the tin annually imported by them is given at $14,000,000. It is stated that they have bonded the Temescal tin mines from the various claimants to the amount of $80,000, and that the money will be paid on the 1st of May next, and it is believed that the resumption of mining operations will greatly benefit business and property interests in that section.—*Los Angeles Land Journal.*

AWARD OF THE BESSEMER MEDAL.

THE gold medal which was placed at the disposal of the council of the Iron and Steel Institute two or three years ago by Mr. Henry Bessemer, to be conferred from time to time upon persons who had effected great improvements in the manufacture of iron and steel, is to be awarded this year to Mr. Robert Mushet. Both on his own and his father's account, Mr. Mushet is well entitled to receive this distinction. David Mushet was one of the most conspicuous characters of whom the Scotch iron-trade can boast. He entered the Clyde Iron-Works as accountant in the year 1792, when he was nineteen years of age, and left in 1800, becoming in the interim one of the most skillful assayers of his time. While engaged in the following year in the erection of Calder Iron-Works for himself and partners—the chief of whom was the elder Mr. William Dixon, of Govan—he made the discovery of the black-band ironstone, a discovery to which may be traced a large share of the influence which Scotland has since acquired in the iron manufacture. His "Papers on Iron and Steel," published in 1840, is still quite a classic work on the subject which it treats of. Like his father, Mr. Robert Mushet has been long and intimately identified with improvements in making iron and steel. One of those improvements, patented in 1856, consists in adding liquid spiegeleisen to decarburized pig-iron so as to produce steel—a process which has since proved to be a most important element in rendering the Bessemer process such a great practical and commercial success that it has now effected a complete revolution in the trade of steel-making.

CRYSTALLINE SURFACES ON METALS.

AT a meeting of the Scottish Society of Arts, recently held at Edinburgh, Mr. Alexander Gowans, one of the vice-presidents, in the chair, Dr. Stevenson Macadam made a verbal communication on "The Production of Crystalline Surfaces on Metals."

In the course of his remarks he stated that two years ago he had had occasion to make a number of experiments in regard to the production of crystalline surfaces on tinned, iron and other coated metals. He ascertained that the best method of producing them was by the employment of an acid mixture containing three parts of hydrochloric acid and one part of nitric acid, diluted with an equal bulk of water. It was necessary merely to immerse the tin plates in the mixture for a period not exceeding ten seconds, the plates afterwards to be thoroughly washed with water, the result being the development of a crystalline appearance which was apparently as durable as the ordinary coating of tin. In order to vary the size of the crystals the tin plates had to be slowly cooled when large crystals were required, and quickly cooled, as by immersion in water, when small crystals were desired. With regard to the question of cost, this process was at least 100 times cheaper than by electricity, and in every way more workable. A thousand square feet of tin plate could be crystallized, so far as the cost of the acids was concerned, for 7*d.*

In the course of a discussion which followed, Dr. Ferguson described Dr. Macadam's process as being precisely the same as the deposition of water on a frosted pane. If there was a comparatively weak frost beautiful large crystals were formed; if sudden or severe frost, the smaller or frosted appearance was the result. Mr. Sang, secretary, and several others joined in the discussion, the tenor of their remarks being that the process described was not a new one, but simply the revival of one known upwards of fifty years ago, which came suddenly into fashion but went as suddenly out. Dr. Hunter, late of Madras, mentioned that he had seen this kind of work in Yokohama, and, indeed, it was in very great perfection among the Chinese and Japanese, and also among the natives of India. Dr. Macadam, in the course of a brief reply, expressed the opinion that there were many ornamental uses to which this kind of crystallization might be applied.

SOFT IRON *VERSUS* HARD STEEL.

MR. ISAACE REESE, of Pittsburg, has an invention for cutting bars of hardened steel, which was described by Professor B. S. Hedrick before the American Association for the Advancement of Science, Detroit. He said the development of heat by friction has been long known. For some time it has also been known that the operations of rubbing and rolling had the effect of changing the molecular structure of iron and steel. These operations will toughen and compact cold iron, and will harden and condense steel. Some time since Mr. Jacob Reese, of Pittsburg, Pa., had occasion to construct a machine for cutting bars of cold-hardened steel. For this purpose he mounted a disk of about forty-two inches diameter, made of soft wrought iron, upon a horizontal axis, so as to be rotated with great velocity. With any moderate speed no cutting was produced. But on giving the disk such a speed of rotation as to cause the periphery of the disk to move at a velocity of about 25,000 ft. per minute—nearly five miles—the steel was rapidly cut, especially when the bar to be cut was slowly rotated against the disk. Sparks in a steady stream were thrown off. But on examining the pile of accumulated particles beneath the machine they were found to be welded together in the shape of a long cone, similar to the stalagmites in the limestone caves; they were nearly like the spikes of frost as formed in winter on Mount Washington, and illustrated at the Troy meeting. Real fusion takes place. The steel is melted by the swiftly-moving smooth edge of the soft iron disk, but the disk itself is but little heated. The bar of steel on each side of the cut receives but a slight heat, not at all drawing the temper, or oxidizing it. By this process a rolled, polished, and hardened steel bar of two or three inches in diameter may be cut in two in a few minutes. The soft metal disk of iron used was about forty-two inches in diameter. The particles fly off in a thick jet or stream through which the naked hand may be passed without injury. They glance off without burning the hand, having assumed the condition which causes the spheroidal state of liquids.

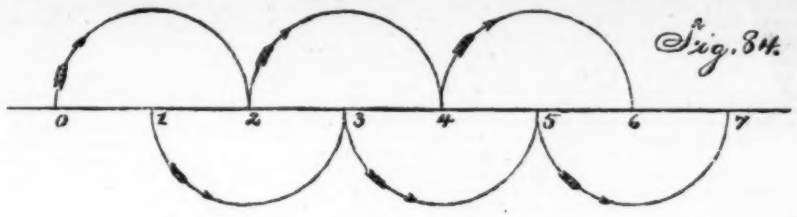


Fig. 84.

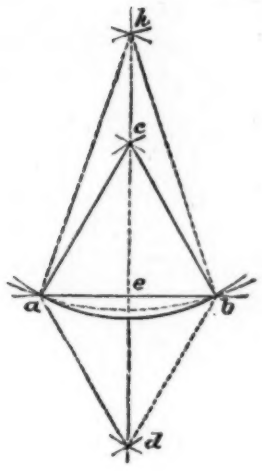


Fig. 85.

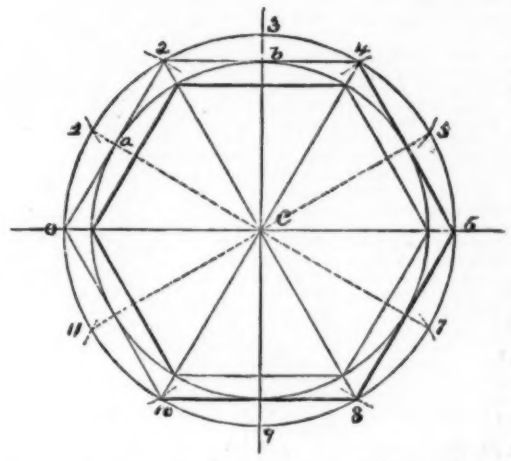


Fig. 86.

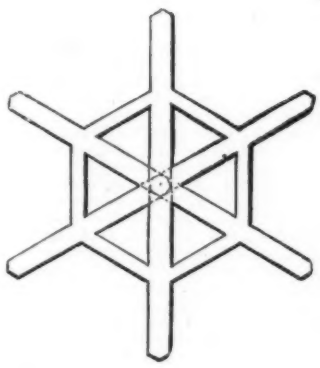


Fig. 89.

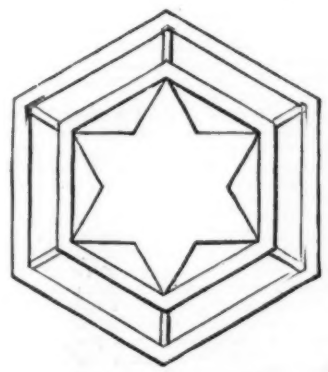


Fig. 90.

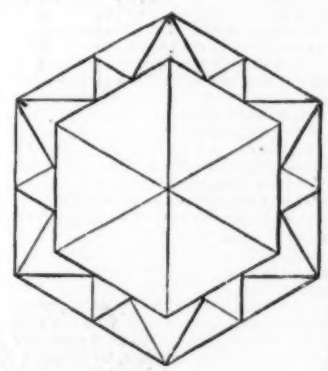


Fig. 91.

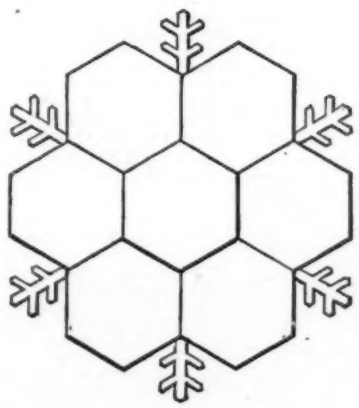


Fig. 87.

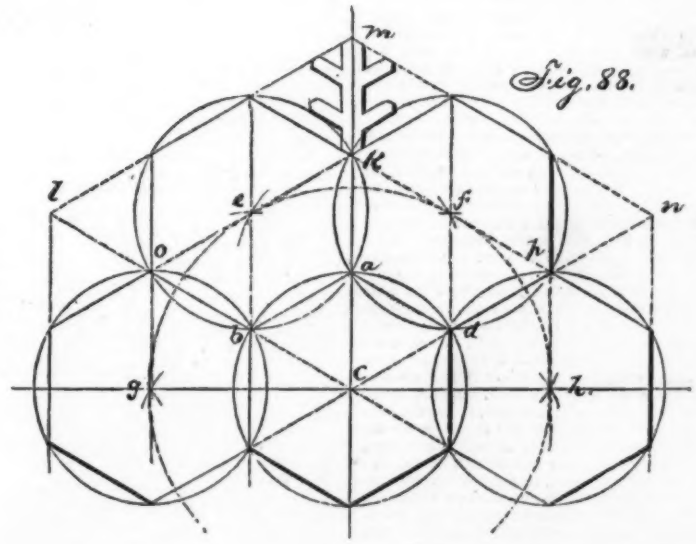


Fig. 88.

LESSONS IN MECHANICAL DRAWING.

By PROF. MACCORD, Stevens Institute.

(Continued from page 220.)

No. VIII.

HAVING in our last lesson described the construction of the compasses and dividers, it is now necessary to explain the mode of using them, for though it might seem that it would be difficult to handle such simple instruments wrongly, yet the fact is that without some instruction the novice is seldom able to do it rightly, and facility in executing work with these, as with many other appliances, depends largely on their being manipulated in a proper manner.

These remarks apply more particularly to the compasses and the dividers; the management of the spring-bows hardly needs a word of explanation, since one could scarcely fail to draw a circle with an instrument furnished like those with a handle at the top, which is merely to be held between the thumb and fore-finger, and turned round by rolling it between them. But as before remarked such a handle does not answer equally well with the larger instruments, which are too heavy to be properly managed in that way, and beginners are very apt to think that they will in some manner escape from them, unless they are firmly secured by a good grip on the outside of both legs. This is a great mistake; there is a liability, amounting almost to a certainty, that undue pressure will be exerted before the circle is completed, altering the radius, and producing that most exasperating result, a representation of what should be a closed curve, but really does not return into itself.

The compasses, then, let it be clearly understood, are to be held by the joint alone; side pressure on that does not tend to alter the adjustment, and by the use of the thumb, fore-finger, and middle-finger, the largest pair of compasses that a draughtsman ought to use can be kept under perfect subjection, and manipulated, when once the trick is acquired by a little practice, with no less rapidity and far greater certainty than if they were furnished with a handle, like their little brothers.

The operation of describing a circle by one continuous motion is illustrated in Figs. 82 and 83, on page 221, SUPPLEMENT, No. 14.

The joint is at first grasped between the thumb and the middle-finger, which press on its flat sides, the first finger, if touching it at all, merely resting lightly on the top. The needle-point being placed at the centre of the circle, the pen or pencil point may be either at the left, as shown in Fig. 82, or a little below the horizontal line, toward the tail of the arrow, which indicates the direction of the rotation, the joint of the compass being rolled between the thumb and the middle-finger, until about half the circuit is completed. It will then be found difficult or impossible for the middle-finger to go farther, but the fore-finger will then be just in position to take its place, and the joint is rolled down the inside of the thumb by it, as shown in Fig. 83, thus enabling the whole circle to be struck at one sweep, without the slightest interruption of the motion of the marking-point, as well as without the least tendency to any alteration in the radius, unless the pressure on the paper be so great as to bend the joints in the middle of the legs of the instrument.

And any such pressure as that, it need hardly be said, is wholly inadmissible. These joints ought to be quite stiff, at any rate; and even were they quite slack, they ought not to yield under the slight pressure, which is all that is required, and in the case of a large compass ought to be, if any thing, rather less than the weight of the instrument; for the draughtsman who aims at the perfection of neatness in the execution of his work ought to train himself to handle his compasses so as rather to support a part of their weight than to add to it. The needle-point should be the very finest and sharpest point that can be made, and if it holds in the paper, that is all that is required; it is not necessary that the hole it makes should go through the paper, nor that it should be so large as to be visible without searching for it. In order to find it again readily when required, a little ring may be lightly pencilled round it, and if, when the drawing is finished, no "centre-punch marks" are to be seen, so much the better.

In regard to the dividers the same general precaution against a change of adjustment is to be taken—that is, they are to be manipulated by the joint only, without pressing on the outside of the legs, while spacing off a line. The art of adjusting them with one hand is readily acquired, and the mode of doing it is so obvious that we need not describe it.

But supposing it to be required to step off a given distance a certain number of times, along a line either straight or curved, there is one thing which a beginner is very apt to do against which it is worth while to caution the reader; that is, to use the dividers by turning them over and over in the same direction. If this be attempted, it will be found impossible to step off the distance more than three or four times without taking up the dividers in order to replace them in the fingers as they were held at starting. This is very inconvenient, and much time is lost by it; and it may be avoided by rotating the instrument alternately in opposite directions as if describing a series of semicircles, first on one side of the line, then on the other, the paths of the feet being as shown in Fig. 84. In this manner the stepping-off may be continued indefinitely, and the dividers managed with great facility and kept under perfect control with the thumb and forefinger only.

Having thus stated what should be done, there is yet a word to add as to what should not be done. The joint on the leg of the compasses is put there, as we have already stated, for the express purpose of setting the needle-point and the marking-point both perpendicular, or nearly so, to the paper. After doing this, we have seen those who seemed to find a perverse pleasure in tipping the whole instrument over sideways so as to mark with the side instead of the end of the pen-blades. And they would gravely argue that inasmuch as the radius was not altered by it, this inclination did no harm, and its amount was a mere matter of taste, without considering that the fixed leg was thereby compelled to describe a cone, just as if the middle joint had not existed.

Now, before returning to our snow-flakes, we may jog the reader's memory lest he accuse us of an apparent inconsistency in having first stated that they were introduced as exercises to be constructed with the triangles, and then interrupted those exercises to give place to descriptions of other formidable apparatus. The utility of those figures as a means of mastering the manipulation of the triangles is not at all impaired by the use of the compasses in so much of the laying out as can be more readily done by their aid; and though very much more can be done with the triangles and a slip of paper than one might at first glance suppose, yet they will not suffice for every thing, and the compasses must be used sooner or later. Those who have them not may, therefore, be consoled by the reflection that they can do a great deal without them, but they must not expect that they can do it as easily or as well as if they had them.

Supposing, then, the compasses to be at hand, they will greatly facilitate the drawing of the snow-flake designs, and not only may but should be used, because the habit should be formed and adhered to of doing whatever is to be done in the best manner first of all, and when there is a choice between methods equally good, of selecting the most rapid. There is at best, in the careful execution of mechanical drawings, enough of work that requires resolute patience, and it is not right to waste time in doing a thing in the most laborious manner merely for the sake of showing that it *can* be so done, if we have the means of doing it *as well* in a more expeditious way.

We shall subsequently give instructions as to the use of the compasses in the *construction*, or laying out, of various problems of use in mechanical drawings, at greater length than would be appropriate here; but in their use as applied to the exercises in hand, one or two elementary points are illustrated in Fig. 85. First, to draw an equilateral triangle whose side is $a\,b$: with $a\,b$ as radius and a as centre, describe a short arc; then, with b as centre, describe another arc with the same radius. These arcs intersect at c, and $a\,c\,b$ is the triangle; another, similar and equal to it, may be drawn on the other side of $a\,b$, as shown in dotted lines, the arcs intersecting at d. If we draw $c\,d$, it will be perpendicular to $a\,b$, and bisect it at e. But any point, as h, in $c\,d$ or its prolongation is equally distant from a and b, so that in order to bisect $a\,b$ we might have taken any other radius, as $a\,h$, instead of $a\,b$ to describe the two arcs with. Again, if we describe an arc about c with radius $a\,b$, it will, of course, pass through a and b: this arc is drawn in a full line, and an arc described about centre h, with radius $a\,h$ (which is drawn dotted), will pass through the same two points, which are equally distant from e; consequently, to draw a perpendicular to $a\,b$ from c or h we have only to describe an arc about either point as centre, with radius long enough to cut $a\,b$ in two points, and then make an intersection, as at d, of two arcs of equal radii, with those points as centres, and then to draw a line through d and the given point c or h. And to erect a perpendicular at e to the line $a\,b$, we set off $e\,a$ equal to $e\,b$, and then bisect $a\,b$ by a perpendicular as at first explained.

These modes of operating are *geometrical*; it will be observed that the triangles are not used, except as rulers. We shall hereafter have occasion to speak more fully about this distinction between geometrical and mechanical drawing, more particularly since much of the former is necessarily involved in the execution of the latter; but for the present we mention these elementary points more for the purpose of suggesting to the reader that when there are two ways of doing a thing, the one affords a good test of the accuracy with which the other has been executed: as in this simple illustration the correctness of a right-angle drawn with the triangles may be tested by constructing it without them as above described.

In Fig. 19 it was shown that a hexagon was made up of six equal, and of course similar equilateral, triangles, having a common vertex at the centre of the hexagon.

If, then, as in Fig. 86, we draw a circle, and any diameter cutting the circumference at the points 0 6, for instance, and then about 0, with the same radius 0 e, draw two arcs cutting the circumference at 2 10; and about 6, with the same radius, two others cutting it at 4 8, the figure 0 2 4 6 8 10 will be a regular hexagon.

The diameter 0 6 being horizontal, if we now draw a vertical centre line, the points 3 9 will be midway between the points 0 6; if then we cut the circumference at 1 5 by arcs still with the same radius, with 3 as a centre, and at 7 11 by others whose centre is 9, we shall have divided it into twelve equal parts.

Such division is frequently required, and it may be effected, as we have indicated by the various diameters drawn, by means of the triangles, provided that they are absolutely accurate. But we wish to call attention to the fact that it requires more time, as the triangles have to be changed and reversed several times, and always carefully adjusted so that the lines shall pass precisely through the centre.

And, again, if the circle be drawn, and the compasses used then for another purpose requiring a change of radius, it becomes necessary to set them or the dividers again for the purpose of dividing the circle by their aid in this way. We wish, therefore, to impress upon the reader that the centre-lines (vertical and horizontal) should be drawn, and the division made *at once* before the radius of the compasses has been changed. The pencil should be kept always carefully trimmed to the keenest marking-edge, in which case the divisions marked by the intersections of the arcs with the circumference will be as well defined as if pricked in with the dividers. And it may be stated as a cardinal rule that when points are to be determined by intersecting arcs, as in the construction of the triangle, etc., in Fig. 85, the pencil-compass should be used, and not the dividers; the same may be said, too, of marking off distances, except when, as in Fig. 84, the operation is to be repeated; an intersection of two pencil-lines, if the pencil is as sharp as it should be, locates a point just as perfectly as a hole in the paper: and such points being often required only in the construction, the pencil-marks may be removed and thus leave no trace.

In Fig. 86 the hexagon 0 2 4, etc., is *inscribed* in the outer circle just as the lesser hexagon is in the inner circle, but the inner circle is *inscribed* in the outer hexagon. The sides of the two hexagons are parallel, which shows that had the inner circle been first drawn with the horizontal centre-line, we might at once draw both hexagons by the aid of the triangles only by taking care to draw the sides of the outer one *tangent* to the circle: thus 0 2 touches the inner circle at a, 2 4 touches it at b, and so on. We might determine the points of tangency if we were to draw the vertical centre-line, and from b mark off $b\,a$ equal to $b\,c$ the radius, and so on, if we choose to use the compasses; or, since the tangent to a circle is perpendicular to the radius at its extremity, we might find a by drawing through c a radius with the 30° end of our triangle, as $c\,a$ 1. But what we wish more particularly to emphasize here is the fact that when the direction of a line is given, as that of 0 2 is, it can be drawn tangent to a curve by the eye alone as accurately as it can be drawn through a point marked on the paper, which is a very important fact, and one which will be found of very great utility in subsequent operations.

In Fig. 87 we have given a design which, like the others, may be executed without the compasses, and in Fig. 88 we illustrate on a larger scale the method of constructing it with them. First draw the centre-lines $g\,h$; $c\,m$. (We may here remark that when there is no reason to the contrary, a mechanical drawing of a symmetrical figure should be made symmetrical about a vertical or a horizontal line, or both: in drawings for practical purposes the mechanic naturally seeks for measurements from such lines, and in future we shall speak of the centre-lines, when not otherwise specified, as having these directions.) About c describe a circle, cutting the vertical centre-line at a; from a with the same radius mark off $b\,d$ (and complete the central hexagon as before explained). With the same radius, describe from a and b arcs intersecting at e, from a and d arcs intersecting at f, and so on round the central hexagon: evidently the intersections $g\,h$ will fall on the horizontal centre-line if the work be accurate. Still with the same radius, describe circles about each of these centres, e, f, g, h, etc., and mark off the angles of the inscribed hexagons in these as in Fig. 86. The side $a\,k$, common to the two upper hexagons, should lie on the vertical centre-line, which is a diameter of the central hexagon; so also $c\,d$ produced should coincide with $d\,p$, a common side of two adjacent hexagons in the outer row; and the diameters of these, again, should be parallel to the sides of the inner one, as $e\,k$ to $a\,b$, and should form the sides of a larger hexagon, a part of which is $g\,o\,k\,p\,h$. And, pursuing the line of speculation mentioned in Lesson VI., the outer sides of the exterior hexagons should when prolonged form by their intersections a still larger hexagon, of which $l\,m$, $m\,n$ are two sides, respectively parallel to $a\,b$, $a\,d$; and these sides also limit the extension of the smaller crystals in the re entering angles of the completed figure.

Since the centres e, f, g, h, etc., are equally distant from c, we might find them by striking a circle about c, with radius equal to $c\,e$ when found as above explained, and then dividing that into six parts. But this would involve either the use of another compass or the changing of the radius from $a\,c$ to $e\,e$, and then back again, and it is therefore better to determine all these centres by two intersecting arcs as described, since then *all* this work, as well as subdividing the circles when drawn, is done continuously without changing the radius at all: and it is always desirable to do as much as possible without readjusting the instruments.

The three remaining figures are given as exercises for practice, in regard to which we shall add but a word in explanation of Fig. 89. The prominent feature of this figure consists of three narrow bars, of equal breadth, whose centre-lines intersect at the centre of the hexagon by which the whole snow-flake may be bounded, like the one shown in Figs. 62 and 63. In such cases as this the best and most rapid mode of proceeding is to draw a small circle of a diameter equal to the breadth of the bar, and to draw the sides of the latter tangent to this circle, as shown in dotted lines. By this means we not only save the trouble of setting off the minute measurements three times, but we avoid the chances of error involved in so doing. It is, however, very essential that the circle shall be true and its centre exactly located, and this the more the smaller the scale on which we work: which goes to confirm what we have tried to impress upon the reader, that in the selection of instruments quality is more important than quantity.

OPTICAL INACTIVITY OF THE REDUCING SUGAR FOUND IN COMMERCIAL PRODUCTS.—MM. AIME GIRARD and LABORDE.—The authors consider it established that there exists in commercial products a reducing sugar having no sensible influence upon polarized light, and consequently incapable of influencing the results furnished by the polarimeter.

[Bulletin of the American Iron and Steel Association.]

IRONWORKS CONSTRUCTION IN 1875.

By GEO. W. COPE.

ALL kinds of manufactured iron and steel, of course including pig-iron, touched lower prices in 1875 than had been known for many years. An unenlightened observer would naturally suppose that under such circumstances, and with the gloomy prospect of even less remunerative prices in 1876, active construction of iron and steel works would cease, and no contemplated works would be put in builders' hands. It is, therefore, interesting to collect facts concerning the building of new establishments in the past year and the starting of works that had been nearly completed in the previous year.

New-England and the Pacific States.—Of all sections of the country in which iron is manufactured, less building was done in New-England and on the Pacific Slope than in any other localities.

Pennsylvania Furnaces.—This State has shown, in the number of new establishments added in 1875, that her citizens still hope for a restoration to activity of the long-depressed iron trade. The Bethlehem Iron Company completed three anthracite furnaces at Bethlehem, in the Lehigh Valley. Two of these furnaces are 70 by 18, with an estimated annual capacity together of 35,000 net tons, but have not yet been blown in. The other furnace is only 31½ by 10½, and was blown in on spiegeleisen August 4th, having an annual capacity of about 5000 net tons. The Keystone Furnace, anthracite, near Easton, was pushed along rapidly in 1875, but has not yet been blown in. Its size is 65 by 16, and annual capacity 10,000 net tons. Durham Furnace, anthracite, at Riegelsville, Bucks County, belonging to the Lehigh Valley group of furnaces, was completed in 1875, but not blown in. It is a large furnace, 76 by 20, takes the place of two small furnaces which were demolished in 1874, and has a probable annual capacity of 18,000 net tons. In the Schuylkill Valley the following anthracite furnaces were completed: Bechtelsville Furnace, at Bechtelsville, Berks County, 63 by 16, annual capacity 11,500 net tons; East Penn Furnaces, two stacks, at Lyons, Berks County, each 48 by 12½, total annual capacity 15,000 net tons; Kutztown Furnace, at Kutztown, Berks County, 54 by 15½, annual capacity 10,000 net tons; Warwick Furnace, Pottstown, Montgomery County, 55 by 16, annual capacity 15,000 net tons; and Sheridan Furnace, Sheridan, Lebanon County, 54 by 16, annual capacity 12,000 net tons. Sheridan Furnace is the only one of these which was blown in during 1875, while the East Penn Furnaces are the only ones to follow its example thus far in 1876. In the Susquehanna Valley, Northumberland Furnace, anthracite, at Northumberland, completed late in 1874, 61 by 18, annual capacity 15,000 net tons, has not yet been blown in; Dock Furnace, anthracite, at Harrisburg, 40 by 11, annual capacity 5000 net tons, finished about the same time, has not been fired; but two of the Coleman Furnaces, anthracite, at Cornwall, Lebanon County, which were built in 1873–4, each 52 by 15, total annual capacity 20,000 net tons, were first blown in late in 1875; the Pennsylvania Steel Company, near Harrisburg, began the erection of a second furnace, anthracite, 60 by 14, annual capacity 9000 net tons, which will be completed early in 1876; and the Rock Hill Iron and Coal Company finished two furnaces, coke, at Orbisonia, Huntingdon County, each 65 by 17, total annual capacity 22,000 net tons, one of which was blown in on January 4th, 1876. An old charcoal furnace at Mount Hope, Lancaster County, which had been standing for several years, was put in blast in 1875: annual capacity, 1500 net tons of cold-blast iron. In the western part of the State some activity was manifested. One of the Spearman Furnaces, raw bituminous coal, at Sharpsville, Mercer County, 50 by 14, built in 1872, and having an annual capacity of 12,000 net tons, was first blown in during 1875; the work on a large furnace, coke, 75 by 20, at Johnstown, Cambria County, was vigorously prosecuted by the Cambria Iron Company, and it is expected to make 20,000 net tons of pig-iron per annum when completed; LeMonte Furnace, coke, 65 by 15, of 14,000 net tons annual capacity, was built at Uniontown, Fayette County, and blown in during January, 1876; and Oliphant Furnace, also at Uniontown, coke, 50 by 11, annual capacity 8000 net tons, was begun in 1875.

Pennsylvania Rolling-Mills and Steel-Works.—While the construction of furnaces was attended with the results shown above, new rolling-mills and steel-works were being built in Pennsylvania. At Bristol, Bucks County, a hoop and bar iron mill was built, with an annual capacity of 1200 net tons. At Chester, Delaware County, a plate-mill was erected which will turn out 4000 net tons per annum. The Glasgow Iron Company began to build a plate-mill at Pottstown, Montgomery County, which is to have an annual capacity of 6000 net tons. The Phœnix Iron Company continued the work of fitting up their new beam-mill at Phœnixville, Chester County, the capacity of which will be much in excess of that of their old mill, which makes 20,000 net tons a year. The Lackawanna Iron and Coal Company completed their new rail-mill at Scranton, Lucerne County, and now have 113 single puddling-furnaces, which is far beyond the puddling capacity of any other establishment in the country; they finished the erection of their Bessemer-steel plant, consisting of two 5-ton converters and all the appliances for making steel rails; the first "blow" was made October 23d, and the first steel rail rolled December 29th. At Milton, Northumberland County, C. A. Godcharles & Co. put their new rolling-mill and nail-works, having 16 nail-machines, in operation on October 28th, with an annual capacity of 1800 net tons. The Pennsylvania Steel Company, near Harrisburg, added two Siemens open-hearth furnaces to their Bessemer-steel plant. Near Pittsburg, the Edgar Thomson Steel Company completed their Bessemer-steel works, making their first "blow" on August 26th, and rolling their first steel rail on September 1st, the plant consisting of two 5-ton converters and a rolling-mill. Messrs. Rogers & Burchfield, Leechburg, Armstrong County, and the United States Iron and Tin Plate Company, McKeesport, Allegheny County, began the manufacture of bright tin plate. At Beaver Falls, Beaver County, Abel Pedder & Co. started their cast-steel works, containing two 24-pot Siemens furnaces. The Crucible-Steel Casting Company built their works at Pittsburg, comprising three steel-cementing furnaces and eight steel-melting holes, with a yearly capacity of 600 net tons. Hussey, Binns & Co., of Pittsburg, added a 24-pot Siemens furnace to their works, and will hereafter make their own cast-steel for their celebrated shovels. C. E. Jones & Co. built the Pitt Steel Works at McKeesport, Allegheny County, putting in a 24-pot Siemens furnace, and will make 1400 net tons of cast-steel a year; also having a forge attached, with an annual capacity of 1500 net tons of charcoal-blooms and hammered bar-iron.

Ohio.—The construction of new works was pushed vigorously in Ohio. The famous coke-furnaces of the Etna Iron-Works, at Ironton, were completed, and one was blown in September 13th. They are supplied with the Ferrie self-coking apparatus and the Whitwell hot-blast, and have a

total annual capacity of 40,000 net tons, each being 86 by 18 Huron Furnace, 49 by 11½, at Jackson, was first blown in on raw bituminous coal April 19th; annual capacity 5500 net tons. Ironton Furnace, 58 by 16, at Ironton, was first blown in September 9th on raw bituminous coal; daily capacity, 50 net tons. The Wellston Twin Furnaces, each 53 by 11½, at Wellston, Jackson County, were finished in 1875, and will be run on raw bituminous coal; total annual capacity, 12,000 net tons. The furnace of the Baird Iron Works, at Gore, Hocking County, was built in 1875, and put in blast on raw bituminous coal; it is 44 by 12, and has an annual capacity of 5000 net tons. Bellaire Furnace, at Bellaire, Belmont County, although begun in 1873, was not blown in until September 18th, 1875. It is a coke-furnace, 65 by 16, and has an annual capacity of 13,000 net tons. Fanny Furnace, 50 by 11½, was built by the Licking Iron Company at Newark, Licking County, and was blown in on raw bituminous coal on May 25th; annual capacity, 6500 net tons. The Cleveland Rolling-Mill Company added two open-hearth steel-furnaces to their Bessemer-steel plant at Newburg, near Cleveland. The Valley Iron Company built a bar-mill at Cleveland, with an annual capacity of about 2000 net tons. At Masillon, Mitchell & Co. put in operation a bar-mill which had been built in 1873, and, until January 4th, 1875, had not done a day's work; annual capacity, 6000 net tons. The Empire Rolling-Mill was removed from Seymour, Indiana, and rebuilt at Cincinnati, O., where it was started up on August 1st, to make bar and hoop iron, having an annual capacity of 5000 net tons. This is practically a new mill, as it had not been fairly in operation in Indiana. The Otis Iron and Steel Company put their new steel works at Cleveland in operation on January 1st, 1875. They make cast-steel as well as open-hearth steel, and have an annual capacity of 4000 net tons.

Summarizing the list, we find that in 1875 there were completed, first put in operation, or begun to be built, 53 furnace-stacks, 3 Bessemer steel works, 1 heavy rail-mill, 17 bar-mills, 7 crucible-steel works, 4 open-hearth steel works, 2 Catalan forges, and 4 bloomaries. Comparing their capacity with the total capacity of the country on the 1st of January, 1876, as given in the Directory to the Iron-Works of the United States, which of course includes in the grand aggregate whatever increased capacity resulted from repairs to old works in 1875, we have the following table showing the percentage of increase.

KIND OF WORKS.	Number of New Works.	Annual Capacity of New Works in net tons.	Percentage of Increase on former Capacity of the Country.
Furnace-stacks	53	622,000	12
Heavy Rail-mills	1	15,000	0.7
Bessemer-steel works	3	140,000	38
Bar-mills	17	83,000	4
Crucible steel-works	7	9,300	26
Open-hearth steel-works	4	16,000	55
Catalan Forges	2	5,000	9
Bloomaries	4	4,300	7

It must be borne in mind, however, that although this detailed statement of the increase in capacity of the iron and steel works of the country seems to contradict the general impression that the iron business does not pay at present prices, yet a great many of these new establishments are standing fireless until better times; many old works are in bankruptcy, and failures are occurring almost every day among manufacturers who were once thought to be past all danger of financial embarrassment. The percentage of increase given above may reasonably be deemed fictitious, because many of the new furnaces will take the place of badly-located or poorly-constructed stacks which will gradually be abandoned. The iron rail-mills will not work up to their capacity for a long time to come, and not a few of them may before long be abandoned in consequence of the use of steel rails, which is very rapidly growing. There are also many bar-mills which have not been running for several years, some of which may never again be put in operation. The past year has, notwithstanding, added much to the capacity of the iron and steel works of the country.

[Franklin Journal.]

ILE'S DIFFERENTIAL COMPASS.

AT the meeting of the Institute, in December last, a model of the working parts of this instrument was exhibited and explained. This compass is intended to show on shipboard any aberration of the steering-needle caused by iron, either as used in the construction of the vessel or carried as cargo, and to enable a mariner to restore true reading by making due compensation.

Its principal difference from the ordinary ship's compass consists in its having two needles suspended in the usual way and placed one above the other at such distances as to preclude undue mutual influences. These needles are constructed of strips of non-magnetic material—preferably alluminum—6 in. long by ¾ in. wide. On the upper one are fastened a large number of minute steel magnets, about ¾ in. long, placed parallel with the body of the needle and the like poles all in one direction. As each magnet tends north and south, the whole needle will point in that direction.

The lower needle is composed of a strip and magnets of the same materials and dimensions, but the magnets are fastened to the strip crosswise with the like poles all in one direction, and as all these magnets tend north and south, this needle will point east and west. The needles are thus constructed in order to distribute the magnetic force evenly through their length and thus cause them to be equally influenced in aberration and compensation.

It is evident that if there be no local attraction, the two needles must stand at right angles to each other, but when such local attraction does exist, it will be detected by the inclination of the needles toward it at an acute angle; the amount of deflection of each needle depending on the position and strength of the local attraction.

Compensation to restore true reading is effected by using the repellent pole of a large bar magnet in either acute angle until 90° is restored. But as the compensator can restore 90° when placed on any line, and as it only gives true results when its direction coincides with the direction of the disturbing cause, the latter is determined by using the bar magnet in connection with a short table to be constructed at the factory and to accompany each compass. When the position of the bar magnet for obainting true compensation has been determined, it is fixed there until there is a marked change in the ship's heading, when it will need to be determined anew.

GEOLOGICAL SOCIETY, LONDON.

AT the last meeting of the above society Mr. J. A. Phillips read a paper on "The Greenstones of Western Cornwall," in which he brought forth evidence to show that the so-called "greenstones of Cornwall," in which he brought forward evidence to show that the so-called "greenstones" of Penzance really belong chiefly to the following three classes:—(*a*) Gabbros or Dolerites, in which the originally constituent minerals are either to a great extent unchanged, or, sometimes, almost entirely represented by pseudomorphic forms; (*b*) killas, or ordinary clay-slates; (*c*) higly basic hornblendic rocks, exhibiting a tendency to baeak into thin plates; these under the microscope present the appearance of metamorphosed slates. The next paper was by the Rev. T. G. Bonney, on "Columnar, Fissile and Spheroidal Structure," in which the author said some of the above structures have comparatively recently been discussed by Mr. Mallet and Professor J. Thomson. Both these authors agree in attributing columnar structure to contraction due to loss of heat while coolIng, but differ in their explanation of cross jointing and spheroidal structure. In this paper it is sought to show that the principle proved by Mr. Mallet to be the explation of the columnar structure is capable of a wider application. After a brief notice of some instances of columnar structure, the author described cases of a fissile structure seen in certain igneous rocks (especially in the Auvergne phonolites), closely resembling true cleavage, and often mistaken for it; also the tabular jointing of rocks; a peculiar form of this, where most of the segments are of a flattened convexo-concave form; spheroidal structure and cup-and-ball structure. He showed by examples that Professor Thomson's explanation of sphereodical structure was inadequate, and gave reasons for considering all these structures to be due to contraction. He also discussed more particularly the cup-and-ball structure, giving reasons for thinking that the sheroidal and the horizontal fissures were often to some extent independent of each other. Mr. Kock stated that he had tried many experiments bearing on the subject of prismatic and sheroidal structure. Slag at 1500° C., when suffered to run into water, has a perfectly smooth surface, and exhibits distinct prismatic structure. Fragments of ironstone placed on the sole of a furnace cracked off in shells, leaving spheres; and quartzite under similar circumstances flaked off in the same way.

BRAIN CHANGES IN HYDROPHOBIA.

IN one of the late numbers of Virchow's *Archiv*, Dr. Bene dikt states that he has examined a number of brains from rabid dogs, and the brain of a man who died from hydrophobia. The results which he obtained, and the conclusions he based upon them, are as follows: Hydrophobia is a poisoning of the blood, which being latent in the brain for a while, breaks out at last. This takes place in certain parts of the brain. In dogs there were found changes in the olfactory gyrus of the anterior lobe, in a fossa which corresponds to the fissure of Sylvius in man, in the lenticular ganglion, and along the trifacial nerve toward its nucleus. The morbid changes seem to begin with a coagulation in the smaller veins, which is followed by increased pressure in the veins. In the course of the now developing inflammation, the walls of the vessels are penetrated by red and white blood-corpuscles. The inner and middle coats of the vessels are torn in some places, while the outer coat probably becomes softened, and then a number of blood-corpuscles may leave the vessels by the openings thus formed. The blood-corpuscles form along the vessels a number of little abscesses in the brain-substance. The corpuscles begin here to swell, and become at last transparent. The pre-existing cellular elements (of the brain) enclosed by the blood-corpuscles also swell, and become hyaloid. At last blood cells and brain-cells are softened, and change into a transparent amorphous mass. The miliary abscesses in the brains of men are arranged in clusters around the vessels. There are also masses of yellow pigment along the vessels. These originate from red blood-corpuscles, which run through all stages of swelling. Only the nucleus is pigmented; there are also free nuclei. The appearance of the hallucinations and illusions, as well as of the motor form of psychosis in hydrophobia, is explained by the locality which becomes in this disease affected in the brain. The author does not deny that there may also be similar changes in a number of other organs.

WALKING AND TRAINING.

THE surprising feats of endurance which the American pedestrian, E. P. Weston, is now accomplishing in London are capable of affording instruction as well as of exciting interest. He has on a former occasion walked 400 miles in five days, and he is now accomplishing, and about to accomplish, feats of endurance even more extraordinary. Athletes generally will be interested to know that he contemns the established rules of training, and that the only preparation which he went through before beginning his present series of walking-matches against time was to pass a few days quietly in the country, taking a ten-mile walk daily. His alleged preference for cold meat as an ordinary diet is founded on error. On Tuesday afternoon, before starting his present 300 miles walk, he dined off a broiled steak. He is not a total abstainer, except when he is walking, and then he takes nothing but cold tea, lemons, and oranges to refresh himself; while for nourishment he relies on soup made from extract of beef. Soups made in the ordinary way he considers too heavy for digestion during his protracted exertion, and finds himself unable to digest them. His ordinary rate of walking is about four miles and a half an hour; his walking is almost entirely from the hip, the knees being flexed, and the knee-joint having very little play. During the first 24 hours he rests for about ten minutes at a time every two hours, during which time he reclines on a couch so arranged that both head and feet are much elevated, the body being doubled up; he is shampooed during these intervals with bay-rum, being rubbed in a direction from the distal end of the limbs towards the trunk. At the end of each 24 hours he takes two hours of sleep, and at this time generally eats a little cold beef. At the end of his greatest walking-feats he has never been exhausted or in any way injured. During some of his longest walks in America he has readily submitted himself to rigid scientific observation, and a series of very important conclusions was drawn from the physiological data thus obtained by Dr. Austin Flint in New-York, which were published in an elaborate monograph, and which Dr. Flint summarizes in his newly-published text-book of "Human Physiology." Dr. Pavy is at present checking these results by an independent investigation, of which he has forwarded us a report up to date, and Mr. Weston has obligingly consented to facilitate on a subsequent occasion a further series of physiological investigations bearing on the waste of tissue, which will be undertaken specially on behalf of this journal. He is by profession a writer for the press; he never bets or backs himself, and has a strong desire to make his powers of endurance useful for the purpose of furthering knowledge of the laws of waste and nutrition and the investigation of the vital phenomena connected with muscular effort. Information on this subject is still much needed, and, when gathered, will have important practical applictions to medicine and to physiology. —*British Medical Journal.*

[N. Y. Grocer.]

THE CHANGING METHODS OF CONDUCTING BUSINESS.

ONE of the most strongly-marked features of the entire revolution in business methods made necessary by the progress of events, is the tendency towards bringing the producer and consumer into more intimate relations and dispensing with the services of middlemen. This is attributable very largely to the wonderful discoveries in electrical science and the remarkable applications of them in multiplying the means of intercommunication throughout the world, and to the constantly increasing and cheapening of the channels of transportation. Geographical explorations and scientific investigations, the results of which have been widely disseminated through the press, have also co-operated to effect this change. We shall not be surprised if the time comes when only the absolutely necessary factor or first hand man and the equally necessary distributor or retailer are the only class of middlemen leaving out of consideration the question of transportation, between the producer and the consumer. At least that such is the tendency will be very clearly seen by noticing what is transpiring before our eyes. A few years ago it was an unheard of thing for an importer to sell direct to an interior jobber, or a large city retailer; now it is becoming quite common. It was equally unknown that a wholesale grocer should manufacture his own spices, coffees, baking-powders, soap, etc., but now the larger jobbing-houses are extensively engaged in doing so. The final result of such changes must be to entirely eradicate that class of jobbers who have heretofore acted simply as distributors, and to give their business to another class who shall be their own importers and manufacturers. As a natural consequence the present manufacturers of grocers' goods will appeal directly to the interior distributing dealers and the retailers, as some are already doing. The problem is not sufficiently solved to determine whether the present class of importers will take the place of the jobbers or the contrary, but we see no reason why the present jobbers of groceries in this city should be forced out of business if they are wise enough to see the tendency and adapt themselves to it. They are perfectly familiar with the machinery for distributing goods and know the wants of the country. It will, therefore, be easier for them to become importers than for the importers to become jobbers. Another reason which must grow more and more influential in determining this charge is the rapid multiplication of interior jobbing-houses. Almost every city throughout the country now has its jobbing grocery-houses which supply to a lage extent the local country trade, and these interior jobbers have the same access to first-hand sources of supply that the jobbers of this city have. This system of business is also rendered more feasible by a large and influential class of middlemen whose ultimate relations to the commerce of the entire country it is at present difficult to foretell. We refer to the brokers, who at present render very important services between the importers and interior jobbers. There need be no apprehension, however, that any of these changes will affect injuriously either the commission merchant or the retailer. Their relations to the commerce of the world are fixed and determined, and while future discoveries in science and their application in the arts may greatly alter even the anticipated changes here foreshadowed, the only effect they will probably have will be to bring these two classes into more prominent and pleasant relations with each other.

BANGOR WATER-WORKS.

THE water-works for the city of Bangor, Maine, have just been completed and turned over by the contractors, the Holly Manufacturing Co., of Lockport, N. Y. The contract was executed July 13th, 1875, and the works were completed January 1st, 1876. The water is taken from the Penobscot River, with a lift of from ten to twenty feet. The machinery consists of Holley's improved, double-acting, four-cylinder, pumping-engine, each cylinder being 12" diameter and 27" stroke, and a rotary pump of a capacity of 16 gallons per revolution, to secure uniformity of flow. They may be disconnected so that any desired number may be run at once. The steam-engine may be worked as condensing or compound. The piston-pumps are capable of delivering 3,000,000 gallons of water in 24 hours, at a piston speed of 90 feet per minute, against a pressure sufficient to supply the upper stories of houses on ground 200 feet above the works and two miles distant. The length of piping is about 14½ miles, all sizes, 16" to 2" cast iron pipes. The contract price for works complete—hydants, gates, etc., but including three 84" diameter turbine-wheels, wheel-house, pit, raceway and accessories, in place of the steam engine was $186,000.

The tests required by the contract, as to strength of pipes and ability to throw water from hydrants, were all met previous to January 1st, in full accordance with the requirements. 12 one-inch simultaneous streams were thrown to an average height of 130 feet, on ground at about the level of the pumps. From an elevation of upwards of 100 feet 8 one-inch streams were thrown at once from 130 to 150 feet high. At an elevation 150 feet, 6 streams 130 feet high; at an elevation of 200 feet, of 4 streams 120 feet high, besides at the same time a 2-inch stream on the low level, 175 feet high. The contract called for streams of 100 feet only. On the hill 200 feet above the pumps, and two miles distant, a good play was made through 2700 feet of hose. One three-inch stream reached a height of 240 feet.—*Engineering News.*

Nature says that not long ago an American lady ascended not only to the Grand Mulets but to the summit of Mon-Blanc itself when the temperaure was minus 25°. She reached the top on January 31st at three o'clock in the afternoon, when the sun lighted up an immense panorama. The thermometer marked at the Grand Mulets 13° and the Grand Plateau — 19°. The lady had with her several guides and slept at the Grand Mulets on the evening of January 31st, returning by La Vallé on February 1st. She was enthusiastically welcomed by the inhabitants of Chamounix.

NEW-GUINEA AND THE ADMIRALTY ISLES.

NEW-GUINEA, or Papua, one of the largest islands on the globe, is in its interior even less known to the civilized world than the interior of Africa. It lies north of Australia, from which it is separated by Torres Straits, and its general direction is W. N. W. and E. S. E. It is almost divided at its northern part by an arm of the sea, which reduces its width to an isthmus about twenty miles across; but at other parts of the island the width is from two to four hundred miles. Its length is about fifteen hundred, and its area is computed at about two hundred thousand miles. Little is known of the island except from the reports of navigators who have cruised along its shores; and the latest contribution to our knowledge of the island and its curious inhabitants comes from the report of the British discovery-ship Challenger. Papua was discovered by the Portuguese in the beginning of the sixteenth century, and visited in the same century by the Dutch. On the strength of surveys made by their navigators the Dutch claim the western half of the island, and in 1828 erected a fort on the south-western coast; but their hold is precarious, and may be termed merely nominal.

The Challenger anchored near the mouth of a large river called the Ambernoth, or Ambernon, in January, 1875. A vast delta is formed by the waters of the river which reach the sea by many channels, bringing down alluvial deposits, and filling the estuary, or mouth, of the river with trees and branches. Collecting the waters of an immense mountain-chain, the river brings down specimens of all kinds of vegetation in its rapid descent. One can collect examples of fifty different species of plants without landing, botanizing in a canoe. These circumstances lead to the inference, from the velocity of the rivers, that the mountain-tops in the unknown interior must take rank among the highest in the world. As the voyager nears the shore he is struck with the marvelous growth of the trees and abundance of the vegetation crowning the mountain-sides, and covering the shore.

It was evening when the Challenger dropped anchor in Humboldt Bay, and hardly had she done so when numerous canoes put off from the shore to reconnoitre. As the inhospitable character of the Papuans is well understood from all previous navigators, no attempt at making an acquaintance was essayed at night. At sunrise the next day the Challenger was surrounded by a flotilla of about eighty pirogues, or canoes with outriggers: evidently the island navy, as no woman was seen on board of them. The boats were about twenty feet in length, with a raised deck or platform amidships, on which stood warriors armed cap-a-pie. The rowers sat in the bow and stern, and each boat could carry about five or six men. The attitude of the islanders toward strangers, as described by Entrecasteaux in 1793, and confirmed by Dumont d'Urville in 1827, has not changed. It is hardly their fault, with the experience which the inhabitants of the islands have had with strangers.

The arms of the Papuans are finished with great care and no small degree of skill. They have stone hatchets, polished, analagous to those which belong to the "stone age" of antiquity. Their bows are made of a very hard wood, and their arrows, though five or six feet long, are very light. Like all savages a little advanced, they have a decided taste for bizarre sculpture; and the prows of their canoes are elaborately carved and ornamented. The timorous and suspicious character which D'Urville gives these people was shown in all their conduct. They never dared to strike the first blow; but supposing they were to be attacked when they saw the screw of the Challenger in motion, they showered upon the vessel a cloud of arrows. This was responded to by a broadside of blank cartridges from the Challenger. When the islanders saw the vessel move of herself, as it were, they could not withhold their wondering applause, expressed by shouts, the "chief of the orchestra" leading the concert by blasts on a conch-shell. But not all their admiration could dispose them to give the intruders a welcome.

When the steam-launch was lowered to prosecute the survey of the coast, the canoes of the natives flew before it. And when, for the purpose of observation, the launch approached a village, the natives took a menacing attitude, but retired in disorder when the English landed. The village in the engraving (from a drawing by a member of the expedition) recalls the discovery of the remains of towns on piles in the lakes of Switzerland. The piles are tall enough to keep the huts above the highest tides. They communicate with the land by a plank, which the householder draws in when he would be undisturbed in his home. Such is the commencement of drawbridges and fortified houses which the dwellers on the water's edge erected to guard against formidable enemies. The enemies of the Papuans are the wilder tribes of the interior, who are said to live without houses, in the trees or in caves. It would appear that they make frequent terrible irruptions upon the coast dwellers, who always speak of them with terror. These huts are of very simple construction. The essential part is a mast eighteen or twenty feet high, to which are fastened the inclined pieces, which bend gracefully under the weight of the thatch of foliage.

The Papuans have not the short, woolly hair of the true negro, but longer yet crisp, true hair, of which they are very vain. Civilized belles are not the originators of the "chignon," for the Papuans have for ages added formidable perukes to the hair which nature has given them. Their heads have the circumference of a large hair-bonnet. This rude head-dress would be hideous if it were not for the natural flowers which are fastened in it, far exceeding the best artificial ones in delicacy and beauty. The teeth of the Papuans are blackened and ruined by the chewing of betel; their ears are deformed by the monstrous ornaments which they attach to them. Their noses, which have a natural tendency to spread, are artificially compressed, yet they are not so very repulsive in appearance as one might think. Their tattooing is not exaggerated, and the colors with which they variegate their bodies harmonizes well enough with their natural skin, which is not black, but copper-colored—at least in the sun. The women are not so good-looking as their husbands, but are watched over by them with careful jealousy. Men and women wear a sort of apron about the loins; children and unmarried girls go entirely naked. In the very limited intercourse which was possible with the suspicious natives, quarrels were on one or two occasions narrowly escaped, though a small traffic was accomplished. To avoid the danger of getting into a misunderstanding which should cause bloodshed, the captain of the Challenger abandoned his first intention of making excursions into the interior, and stood away for the Admiralty Islands, a cluster to the north-east of Papua.

The reception given to the English by the inhabitants of these islands, men, women, and children, was very cordial. A brisk trade sprang up, and the shore resembled a fair-ground. The principal articles which the natives had to offer in exchange were shells, lances, stone hatchets, stone ornaments for the nose and ears, rosettes of small white shells, and very beautiful drinking-cups, carved in wood. What they desired above all in return were articles and utensils of iron. Since the voyage of d'Entrecasteaux in 1792, no European is known to have set foot on the shores of the islands which the Challenger visited. The astonishment of the natives at the sight of white faces may be imagined.

These people are of the same race as the Papuans, but much more civilized, and without the mingled fear and defi-

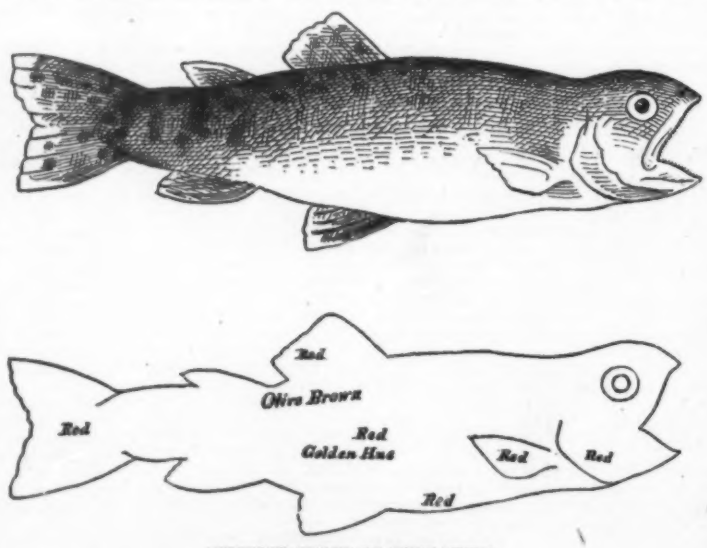
TRAFFICKING WITH THE NATIVES.

ance which their cousins exhibited. This is probably due to the fact that they are not, like the Papuans, exposed to incursions from more savage tribes. Their pirogues have three or four times the capacity of those of New-Guinea. Their villages are embowered in verdant trees, and surrounded by palisades fifteen feet high. The streets and squares are well planned, and their mode of life as far advanced over the Papuans as is their character. The English *voyageurs* saw no traces of graves, and certain information leaves no doubt that on the Admiralty Isles they honor the memory of their parents by eating their dead bodies.

THE KERN RIVER REGION AND THE NEW SPECKLED TROUT OF KERN RIVER.

TO THE EDITOR OF THE SCIENTIFIC AMERICAN:

Noticing in your tenth number Mr. Hutching's discovery of a beautiful new fish in the head waters of Kern River, the undersigned hereby submits a drawing from a sketch, made by him on the spot August, 1867, of a fish caught in a branch of the south fork of Kern River, on his surveys under the auspices of the California State Geological Survey



SPECKLED TROUT OF KERN RIVER.

of the Sierra Nevada south of Mount Whitney, adding some remarks upon that interesting region.

The fish appears to be a species of speckled trout with golden-hued lower sides and head, red fins and gills, and is of dark olive color, with darker spots along the upper part of its sides. The specimen in question was 10 inches long.

The south fork of Kern River—the proper name for which should be east fork, for its main course is south like that of the main Kern River—heads a few miles south of Mount Whitney (15,000 feet high) and after circling the west of Sheep Mountain as a small stream only about 8 feet wide, traverses in a southerly course the high plateau, constituting here part of the main chain of the Sierra Nevada, at an elevation of 9000 to 10,000 feet, where it forms with numerous small tributaries a continuation of meadows, Monatchay Meadows. Though somewhat difficult of access, herders of California have occasionally, at seasons of excessive drought in the California valleys, saved their cattle by moving them to these extensive meadows as early as the melting snows will permit. Rugged and mostly timbered mountain ranges east and west close in this meadow valley, nearly 30 miles in length, which terminates southwards in an exceedingly broken granite region, suggesting the denomination of "The Needles," through which the river tumbles its formerly placid waters; and finally issuing from the mountain fastnesses by a gorge, abruptly turns to the west, traversing another valley leisurely to join the main Kern River some miles north of the Hot Sulphur Springs, still at an elevation of about 1100 feet, where this river cuts its tortuous channel through the Lower Cañon into the Tulare Valley. West of the main Kern River and up to the Big Cañon, the higher mountains are generally densely timbered to an altitude above 10,000 feet, where the pinion growth becomes stouter and shorter, and still higher terminates at a clearly-defined line about 11,000 feet altitude; the towering peaks above that line, of light colored granite interspersed with regions of dark and forbidding-looking volcanic rocks, are but piles of fragments of frequently colossal size, broken from their solid base by the silent but ceaseless action of the freezing waters that entered the fissures. In these elevated regions, where barren desolation reigns supreme, the operation of the untiring forces may be studied to advantage, transforming the solid mountains into fragments, which burrowing animals of various kinds—amongst these a very numerously represented small squirrel—assist to disintegrate into suitable material for the alluvial soil of the fertile plains below.

The timbering is generally less dense along the range between the main and the south fork of Kern River, while it is still more open in the easternmost range along the foot-hills of Sheep Mountain (12 miles south of Mount Whitney) and Rudolph (12 miles further south). Still further south along this eastern range the arid air of the adjacent desert soon exerts its influence, as the gray, barren aspect of the ridge plainly denotes, towards the south.

From the slab of rock that forms the apex of Rudolph Mountain (above 12,000 feet high) a wonderfully variegated view is presented. It is at the brink of a terrible abyss, yawning towards the east, 8000 feet deep, and for over 40 miles southwards to Owens Peak in a generally straight line: a nearly perpendicular rugged precipice of 4000 to 5000 feet, with more or less gentle slope at its foot for some thousands of feet more into the Owens valley. Deep azure, the large Owens Lake, with its white fringe of salt and its background of desert and Coso Mountains, lies at our very feet, towards the north-east, and though four miles distant, it seems near enough that a pebble might be tossed into it from our altitude. The vast expanse of the sun-parched desert below, forming nearly one half of the field of vision, is traversed by range after range of barren-looking mountains, all lower than the observer, and the varied gaudy still sombre hues of their—mostly metamorphosic—rocks are spread like a map under a cloudless sky, and assume more and more the indigo tint of distance till they blend with the horizon probably 200 miles away. To the north the panorama takes in the towering masses of the highest portion of the Sierra Nevada, with its giant sentinels Mounts Whitney, Tyndall, Williamson, Kawiah Peak, and a multitude of others, about which the thunder-clouds of August (24th) then already were gathering darkly and threateningly. Along the foot-hills towards the west the peaceful Monatchay meadows with sandy banks, beyond which the timbered ranges at both sides of Kern River (not itself visible) and southerly the sharply-defined mass of granite columns, The Needles.

At the foot of Kawiah Peak, fantastically-pinnacled mountain above 14,000 feet high, the Kern River enters the Big Cañon, a narrow defile of about 16 miles in length through the rocks that rise abruptly and generally perpendicularly 3000 to 5000 feet; the direction of the defile is due south and in a straight line, so that from a certain peak south of it a view is obtained through the cleft of the large dark basin in which the Kern River heads, crowned by the glorious peaks surrounding it. Probably somewhat more difficult of access than the Yosemite, and not able to boast of its numerous waterfalls, the Big Cañon of the Kern River embraces sceneries equal in grandeur and loveliness to many of Yosemite's most famous.

Even the attraction of the big trees, the *Sequoia Gigantea*, on the way to these wild romantic regions is not wanting, as two extensive groves, each several miles in extent, were discovered by your correspondent in 1867 at the head waters of Tule River, each certainly containing thousands of specimens of this famous tree. The northerly grove, trees in which were measured of 97 feet circumference by nearly 300 feet height, rises to the highest altitude known for these trees, 8500, feet, covering a steep, rocky ridge which divides the waters of Kawiah Creek and Tule River. Near its top, the force of high winds to which they are exposed has denuded numbers of their upper limbs, the stumps of which only remain on the trunks, which have thus the appearance of church-spires. The other grove, about 20 miles south of the first-mentioned, is at an elevation from 5500 to 6500 feet, and contains a great number of magnificently symmetrical groups of 3 to 6 trees 40 to 60 feet circumference, with many of much larger size. Unlike the first, in which many trees cling to abrupt declivities of nearly naked rock, the second grove is on delightful valley-ground, full of fine rivulets, a quiet, secluded place. Even thirty miles further south still, some bark unmistakably of the *Sequoia* was picked up at the said survey in the North-Greenhorn Mountains, proving the existence of these trees in the mountains named, though, it seems, not mentioned before. The occurrence of the *Sequoia* at the spots indicated finds its explanation in favorable conditions of temperate climate and abundant precipitation of moisture even in summer season, when no rain falls in the valleys of California, while thunderstorms are gathering in periods of July and August day after day in the high mountain region described, culminating in rain (or snow) about noon, which even may continue to fall for a day or two in succession in altitudes above 4000 feet.

R. D'HEUREUSE.

NEW-YORK, March 10, 1876.

THE first number of an Arabic newspaper has just been issued in Paris, edited by M. Florian Pharaon. It is intended for the instruction of the Arabs in Algeria.